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APPENDIX I

Unclassified

Research and Exploratory-Development Event Descriptions

PROJECT HINDSIGHT--TASK I

A STUDY OF THE

RESEARCH AND EXPLORATORY-DEVELOPMENT ORIGINS OF

THE NAVAL MINES MARK 56 AND 57



1 JUNE 1966

Prepared by

Naval Ordnance Laboratory (White Oak)

for the

Office of the Director of Defense Research and Engineering
Washington, D.C. 20301

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## RXD Event Description

1. Title: Conception and Feasibility Demonstration of a Simple Tester for Nonmagnetic Materials (#37)

2. System: Mines Mk 56 and Mk 57

3. Subsystem: Actuation (Magnetic Influence)

4. Element: Test and Evaluation (Equipment)

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the conception and feasibility demonstration of a simple tester capable of GO--NO-GO type permeability tests on material samples with permeability approaching unity. The tester may also be used to screen small parts for excessive magnetic effect and, when adjusted for maximum sensitivity, will detect minute magnetic impurities in essentially nonmagnetic materials.

The tester consists of a stabilized and calibrated cylindrical bar magnet horizontally suspended by a fine nylon cord. The suspended magnet is sheltered in a housing to prevent air currents from setting the magnet in motion and to prevent direct contact between the magnet and the sample being tested. The housing is made of transparent plastic for maximum visibility, except for the bottom which is polished aluminum. The latter quickly damps out oscillations of the magnet and, as the image of the magnet is clearly visible, it aids in detecting very slight magnet motion when testing material samples or parts having only a trace of magnetic contamination.

b. Relationship to Contemporary Science and Technology:

At the time of this event the Test Set Mark 115 Model 4, a complex electronic test set with a long manufacturing lead time, was used to test for maximum magnetic effect, as required by the specifications for the components associated with the firing system (and the mine case itself) of Mines Mark 56 and Mark 57. That set did not give any quantitative information on permeability.

Prepared By: Arthur W. Obenschain, NOL(WO) Date: 8 Mar 66

5. Technical Significance:- Continued

In addition, it is a complex electronic test set costing about $3,000 and requiring periodic maintenance. This tester costs approximately $75 and is essentially maintenance-free. This is the first known example of combining a number of existing principles into a simple device inexpensive to construct, rapid in operation, yet capable of detecting even in a noisy magnetic environment the magnetic effects of materials and articles having a permeability approaching unity. Also, its sensitivity can be readily varied by means of a simple adjustment. It is delineated in detail in U.S. Patent No. 3,153,191, Oct. 13, 1964.

c. Relationship to Succeeding Development or to System Performance:

This event provided a fast, low-cost device that was used in place of the expensive, time-consuming, conventional low-mu permeameters usually employed to check piece parts of the Mines Mark 56 and Mark 57 for compliance with their critical permeability specifications. The device is also used to screen easily and rapidly small components, such as resistors and capacitors, to prevent the inadvertent use of magnetic parts in or near the firing system where they are prohibited.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

E. A. Schuchard, Chief, Magnetics and Electrical Division, Naval Ordnance Laboratory (White Oak). Cited the need to replace the existing system for nonmagnetic testing, and asked Obenschain to attempt a solution.

A. W. Obenschain, Supervisory Electronic Engineer, Naval Ordnance Laboratory (White Oak). Conceived the simple tester which constitutes this event and was co-inventor with Nicholson of the final apparatus.

J. E. Nicholson, Electronic Engineer, Naval Ordnance Laboratory (White Oak). Assisted Obenschain in the development of the tester and contributed to it as co-inventor.

7. Key Personnel:- Continued

Mildred Eastburn, Electronic Development Technician, Naval Ordnance Laboratory (White Oak). Constructed a prototype.

8. Date of Event:

a. Termination: 1960

b. Initiation: 1960

9. Duration: One week

10. Organization:

a. Naval Ordnance Laboratory (White Oak)

b. Underwater Electrical Engineering Department

c. Magnetics and Electrical Division

d. Magnetometer Influence Branch

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source - Bureau of Naval Weapons funds on Weptask Assignment No. RUUO 2E51/212 1/F008 for Mine Firing Mechanism Mk 26 Mod 0 Development and Evaluation.

b. Duration - One week

c. Amount - $250

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

Time did not allow the introduction of this device for use on the

13. System Interface Activity:- Continued

Mine Mark 57 OPTEVFOR production. Instead, the Test Set Mark 115 was used for testing this small lot, at a cost of approximately $70,000. It was obvious that the demand for Test Sets Mark 115 would be sizeable, and the costs involved would be prohibitive if large-scale production was tested in this same manner. Accordingly, before the start of stockpile production for the Mines Mark 56 and Mark 57, NAVWEPS OD 27350 (which describes in detail the manufacture, calibration, and use of the simple tester) was prepared and made a part of the design disclosure for these weapon systems. The new tester has been used successfully on all subsequent production.

b. Previous Activity:

The time and expense required to make permeability measurements with a conventional low-mu permeameater provided the principal motivation for this event. In August 1960 Armand Cioccio, Naval Ordnance Laboratory, White Oak (NOLWO), visited the Naval Ordnance Plant (NOP), Forest Park, Illinois, to provide assistance relative to the manufacture of Mines Mark 57 for OPTEVFOR evaluation. He was advised that testing in fulfillment of the nonmagnetic requirement for most of the items used with or in the neighborhood of the firing system would be prohibitively expensive if conventional procedures and equipments were used. It was apparent that the problem would be relieved if the tests could be carried out with a simple, conveniently maintenance-free tester instead of the complicated and expensive Test Set Mark 115 Model 4, then in short supply, or commercial permeability test equipment.

Cioccio reported this to his supervisor, E. A. Schuchard, Chief of NOL's Magnetics and Electrical Division, and the latter asked A. W. Obenschain of that Division if he had ideas for a simple tester. Obenschain believed that the suspended-magnet test prescribed for screening parts for the Magnetic Anomaly Detector (MAD) might be improved sufficiently to serve the magnetic mine requirements.

14. RXD Event Circumstances:

Obenshain investigated the problem and found that a suspended magnet was very sensitive if material with even a slight magnetic effect was moved so as to set up rotational oscillations of the magnet. However, the oscillations took a long time to die out; they were frequently produced by

14. RXD Event Circumstances:- Continued

air movements rather than by magnetic contamination; and there was the constant danger that the part being tested would inadvertently touch the magnet and thereby both "perm" a piece that otherwise might pass and, moreover, change the calibrated magnet. His experiments also revealed that the suspended magnet was quite sensitive when used as a dip needle. Obenschain then decided to investigate a self-contained device using the suspended magnet as a dip needle in a plastic enclosure (to shield it from air currents) with an aluminum bottom, so that any motion of the magnet would generate eddy currents that would quickly damp out the motion. The proposed device was described to J. E. Nicholson, who prepared the necessary sketches for the enclosure; a prototype was then constructed. A prototype assembly was completed in August 1960 and used to check parts for the Firing Mechanism Mark 26 that had been rejected by the Test Set Mark 115 Model 4 as being excessively magnetic. The new device proved to be equally effective, and it worked well even in magnetically noisy, high-gradient areas, whereas the other test set requires a relatively quiet, low-gradient area. The tests indicated that the simple device would adequately screen out material and parts that did not meets Mines Mark 56 and Mark 57 nonmagnetic requirements. Experience with the simple tester has revealed that, when calibrated with a standard sample with a permeability close to 1.010, it will consistently pass samples with this, or lower, permeability and reject samples with only slightly higher permeability. Once the tester is calibrated with the standard sample, many samples of unknown permeability can be checked in only a few minutes.

15. Sources:

Documents:

NOL Patent Division File on Docket No. D2733, Navy Case No. 31,753.

NAVWEPS OD 27350, 23 April 1963, on "A Simple Tester for Nonmagnetic Materials."

Informal UM-3 File on Simple Nonmagnetic Materials Tester.

## RXD Event Description

1. Title: Development of Reusable Instrumentation To Monitor Shocks of Parachute Inflation, Water Entry and Bottom Impact of Launched Underwater Weapons (144)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Overall

4. Element: Test and Evaluation (Equipment)

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the development of a self-contained, rugged internal system using a special high-shock oscillograph to monitor and record parachute-opening, water-entry, and bottom-impact shocks experienced by an air-dropped mine. Various sensors monitor this experience, starting 5 seconds before aircraft release and continuing through the moment of bottom impact.

b. Relationship to Contemporary Science and Technology:

At the time of this event, the reliable data could not be obtained. This event provided reliable measurements of mine flight and water-entry parameters at all launching speeds and altitudes possible with high-performance aircraft.

c. Relationship to Succeeding Development or to System Performance:

This event substantially improved the operation and reliability of the system by contributing to a better understanding of the shocks experienced by aircraft-launched mines. Use of this instrument also revealed an unexpected bonus. The parachute is released at water impact by a mechanism using inertia weights. Air-drop tests had shown that at low launching altitudes, below 500 ft., this mechanism would occasionally fail to act. It was speculated that the water-entry angle was introducing side loads that handicapped the operation and that the minimum launch altitude would have to be

Prepared By: James D. Byrd, Jr., 495-7212 Date: 5 Mar 66

5. Technical Significance:-Continued

increased--an obvious operational penalty. However, by use of this instrumentation, it was found that the axial shock at water impact was much less than had been presumed. This discovery led to a redesign of the parachute-release mechanism and a consequent lowering at the minimum release altitude of the mine from 500 feet to 200 feet (with some restriction on speed).

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

James D. Byrd, Jr., engineer, Mechanical Evaluation Division, NOL.

Glenn L. Brown, engineering technician, Mechanical Evaluation Division, NOL.

John P. Fox, engineering technician, Mechanical Evaluation Division, NOL.

Each of these men had about 11 years' experience in the testing of underwater ordnance, principally air-launched mines, at the time of the event.

8. Date of Event:

a. Termination: 1962

b. Initiation: 1962

9. Duration: Six months

10. Organization:

a. Naval Ordnance Laboratory

b. Underwater Technical Evaluation Department

c. Mechanical Evaluation Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source-Navy funds under BuWeps Tast Assignment RUME-2B-000/212-1/WF008-20-004, Prob. No. 156

b. Duration-Six months

c. Amount-Estimated $50,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in determining the actual flight and impact shocks experienced by an air-dropped mine. The technique was also used in the development of streamlined fairings for aircraft-carried mines, including the mine Mark 56, and in troubleshooting problems associated with the flight gear.

b. Previous Activity:

The Mine Mk 56 was released to production in 1958, configured for high-speed carriage aboard aircraft at internal (bomb-bay) stations only. A post-release requirement by CNO for a configuration capable of external carriage by high-speed aircraft was confronted with the problem of the high drag of the blunt-nosed mine. Therefore, a fairing was provided to reduce the drag of the exposed store. However, once a mine is released, low drag is a handicap because the mine will soon attain a very fast speed and—at the moment of delayed parachute operation—may experience shocks that would be damaging to the parachute, its inertia release system or other parts of the weapon. A variable-drag fairing was conceived and found useful in avoiding this predicament. To intelligently design this new fairing, it was essential that the shock loads experienced by the mine throughout its air drop be fully known.

14. RXD Event Circumstances: None

15. Sources:

Person Interviewed:

James D. Byrd, Jr., NOL

Document:

Technical Evaluation Report of Mine Mk 56

## RXD Event Description

1. Title: Development of Special Neoprene Compound with High Tear Strength for Sleeves of Swaged Fittings (#71)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mooring

4. Element: Anchors Mk 56 and Mk 57

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event consisted of the development of a new neoprene compound, using a fine-particle silicon filler, which had very high strength, excellent tear resistance, and long life in sea water, for use in sleeves of swaged fittings.

b. Relationship to Contemporary Science and Technology:

At the time of this event, the endurance of the best neoprene compound available was inadequate. This event more than doubled the tear strength of the neoprene. The compound is defined in the military specification WS-2822.

c. Relationship to Succeeding Development or to System Performance:

This event provided a flexible material with superior strength and abrasion resistance. Without it, the life of a very sophisticated, capable, and costly mine was limited by the simple breaking of its mooring. The minimum endurance requirement of one year is now fulfilled for both mines Mark 56 and Mark 57.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

H.E. Mathews, Chemical Engineer, NOL. Developed the special neoprene compound for this underwater application.

Prepared By: S.E. West NOL Date: 26 Feb 66

7. Key Personnel: - Continued

W.D. Bradley, Mechanical Engineer, NOL. Responsible for the design of the sleeve and its incorporation into the mooring system.

8. Date of Event:

a. Termination: 1962

b. Initiation: 1962

9. Duration: Approximately five months

10. Organization:

a. Naval Ordnance Laboratory, White Oak (NOL)

b. 1. Chemical Research Department

2. Non-metallic Materials Division

c. 1. Underwater Mechanical Engineering Department

2. Structures Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons ) funds

b. Duration- Approximately five months; funds were available

c. Amount- Estimated as less than $10,000

d. The amount estimated was that required for development of the neoprene compound. Field tests under service conditions continued for another two years, with funds provided by the Bureau of Naval Weapons.

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event is now used in the mooring systems of several moored mines.

b. Previous Activity:

The steel rope used as the mooring line for both mines Mk 56 and Mk 57 is terminated in swaged fittings which are, in turn, secured to the anchor and the buoyant case. As tides and currents carry the case back and forth above the anchor, the wire rope is flexed at the point it enters each fitting. This continual movement of the rope tends to literally saw it apart as it sweeps back and forth against the projecting shirt of the anchor. If unprotected, the rope will quickly fatigue at these points where bending and sawing is most severe. It was known that in a somewhat similar situation the British provided some protection to the rope by enclosing it in a heavy hose-like jacket at the points of maximum fatigue. The jacket reinforced the rope, and bending was distributed over a large arc rather than a sharp corner. Also, the jacket protected the rope from abrasion against the anchor skirt. Life of the rope was measurably increased by this innovation. NOL had applied this feature to its moored mines but was disappointed by the inability of available materials to survive this severe use. Mooring endurance thus depended in part upon the effective life of the flexible sleeve. In an attempt to gain maximum mine life, NOL undertook to improve the best candidate material, neoprene, by increasing its tear strength and abrasion resistance. Bradley sought the assistance of Mathews, a specialist in elastomers. Mathews believed he could formulate a new neoprene compound with the desired properties. He was successful. The new neoprene compound was formulated, its unique properties were demonstrated; sleeves were fabricated; and the latter were thoroughly tested in NOL's environmental evaluation facilities and later in the field under actual service conditions.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

H.E. Mathews, NOL

W.D. Bradley, NOL

Documents:

Naval Ordnance Laboratory, Notebook Serial No. 96-5543.

# RXD Event Description

1. Title: Conception and Demonstration of a Modular Construction System for Mine Components (56)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Actuation

4. Element: Firing System Mechanisms (various)

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the conception of a system of modular construction for mine components of various types which can be assembled as building blocks to comprise any of a wide variety of firing systems. The event included the feasibility demonstration of the modular concept and the establishment of limiting design parameters.

b. Relationship to Contemporary Science and Technology:

At the time of this event, mine components were packaged at various places and pockets within the mine case in a seemingly opportunistic manner. Assembly was difficult,and misassembly was frequent; replacement of a component by another type was often thwarted because of different envelopes. Space was not used efficiently because there was no standardization of shape and no uniform means of securing each component in place. This event constitutes an advance in the technology of packaging ordnance mechanisms and their associated power supplies. The basic concept and details of the design are set forth in disclosures for U. S. Patents No. 2947249 and No. 3101388.

c. Relationship to Succeeding Development or to System Performance:

This event improved system performance by simplifing the assembly of the mine; the components themselves are held in a manner more suited to high-shock usage. In part because of this modular concept, mines Mark 56 and Mark 57 can each be assembled and checked out in less than one-third the time required for their predecessors (mines Mark 10 Model 9 and Mark 10 Model 3, respectively).

Prepared By: Leon J. Lofthus, 495-7669 Date: 11 Jun 66

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

C. C. Vogt, mechanical engineer, Mine and Depth Charge Division, NOL. Was in charge of a group responsible for the design of mine structures, mechanisms, flight gear, and test sets.

H. W. Semon, electrical engineer, Mine and Depth Charge Division, NOL. Worked for Vogt and was responsible for the design of certain elements of the mine structure and for several types of internal components. The two men cooperated in this event and are recognized as co-inventors of the two patents issued.

8. Date of Event:

a. Termination: 1948

b. Initiation: 1948

9. Duration: Two months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source-Navy (Bureau of Ordnance) funds

b. Duration-Two months

c. Amount-Estimated as less than $10,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

As a result of this event, very complex mines now are easily assembled with little risk of error, and the conversion from one system to another is quickly accomplished.

b. Previous Activity:

This event was motivated by an awareness by Vogt and Semon that the existing system of component packaging was inefficient regarding space, awkward regarding the introduction of different or new components, and vulnerable to operator misassembly. These deficiencies restricted the flexibility and usefulness of the mines.

14. RXD Event Circumstances:

Various components comprise a mine's firing system, including magnetic, pressure, and acoustic firing mechanisms; arming and sterilizing switches; actuation counters; clock delays; and control boxes and batteries. These components are used in many combinations to achieve particular target-detection and classification capabilities and to confound countermeasure attempts. Heretofore, such components--variously shaped, some in cylindrical and others in box-like envelopes--were assembled into the mine and individually secured. To change a firing system, it often was necessary to alter the bulkheads and pockets in order to hold alternate devices of different shapes. Thus, substitution of components was difficult and interconnections were awkward. Wiring was essentially point to point, and no central test points were provided. This situation resulted in the creation of the "module concept" for mine components wherein uniform, box-like envelopes and standardized connectors are used. Any combination of components, harnesses, and batteries can be housed, brick-like, in a tray-like rack which will hold them in place and protect them from damage when the mine strikes the water or the bottom. Further, because the rack is separable from the explosive-loaded mine case, all assembly and checkout of the firing system can be accomplished away from the case and without hazard. The combination of various parts to configure a wide variety of firing systems is easily

14. RXD Event Circumstances:-Continued

accomplished, and interconnections are made quickly and foolproof by use of molded electrical harnesses that cannot be misassembled. System testing is facilitated by the incorporation of test points focused into a single plug.

15. Sources:

Persons Interviewed:

Charles C. Vogt, NOL

Documents:

Disclosures for U. S. Patents No. 2947249 and No. 3101388, NOL files.

## RXD Event Description

1. Title: Conception and Feasibility Demonstration of a Technique To Dislodge Mine Case from Mud by Generating Volume of Gas (#72)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mooring (Mine Mk 57)

4. Element: Mud Agitator Mk 1

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event consisted of the development of a new technique to free a mine case entrapped in a mud bottom. A self-contained, water-tight "mud agitator" is installed in the existing cavity between the case and the anchor. The device uses a rocket propellant to generate gas; it is actuated at the end of the delay period, whereupon it generates and releases a volume of gas at the case-anchor interface to push against the case. As the gas escapes the cavity, it travels upward along the case to break the grip of the mud and allow the case to continue to ascend.

b. Relationship to Contemporary Science and Technology:

The mines Mark 56 and Mark 57 are required to postpone their mooring operation for selectable periods of time after planting. While sitting on the bottom, they are not vulnerable to sweeping operations directed to cutting their mooring lines. However, during this inactive period, while the buoyant case is married to its very heavy anchor, the total assembly tends to sink-- post-like-- into the bottom. If the bottom is soft, the assembly often will sink until the case is mired in the mud to the extent that it is entrapped and unable to ascend toward the surface when it is unlocked from the anchor. This event provided a positive thrust to the case and, at the same time, disrupted the mud to free the case so that buoyancy alone could carry it upward.

c. Relationship to Succeeding Development or to System Performance:

This device improved system performance by permitting use of the mine Mark 56 and Mark 57 in areas where mud bottoms exist.

Prepared By: F. W. Scott
F. Peregrim

Date: 21 Feb 66

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

H. C. Thoden, Chief, Cases and Anchors Branch, NOL. Conceived jointly with Moore the overall system for dislodging mine cases from mud bottoms by using a gas generator.

H. H. Moore, Mechanical Engineer, Cases and Anchors Branch, NOL. As assistant to Thoden, he contributed to conception of event.

W. B. Johnson, Engineer, Cases and Anchors Branch, NOL. Designed and tested experimental models.

F. Peregrim, Engineer, Cases and Anchors Branch, NOL. Designed and tested experimental models.

C. L. Wagner, Engineer, Cases and Anchors Branch, NOL. Designed and tested experimental models.

F. S. Scott, Engineer, Cases and Anchors Branch, NOL. Designed and tested experimental models.

8. Date of Event:

a. Termination: 1957

b. Initiation: 1955

9. Duration: Approximately two years

10. Organization:

a. Naval Ordnance Laboratory

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

d. Cases and Anchors Branch

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds

b. Duration- Approximately two years

c. Amount- Estimated $100,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This device was used in the mines Mark 56 and Mark 57.

b. Previous Activity:

When tests confirmed that the mine cases could be entrapped by mud, means had to be found to free them. This need motivated the effort which culminated in this event. The idea of freeing the case from mud by releasing gas was conceived as a possible solution. Various schemes of generating a volume of gas were tried; slow-burning explosives were found too violent for the purpose and typical gas bottles were not sufficiently powerful. Not until the rocket propellant was tried did the system produce enough gas to release the case from a mud bottom at maximum planting depth. No money was available for full-time investigation of this event.

14. RXD Event Circumstances:

The operational requirement for a delayed mooring capability for the Mines Mk 56 and Mk 57 was well founded; if it could be accomplished, the enemy would be unable to sweep the mines throughout the delay period; he would nevertheless be compelled to continue his attempts until all prospects of active mines had been erased. If he gave up too soon, the next day might find that a new crop of mines had automatically sprouted up. The tactical advantage of such a system was thus very real, and any problem which tended to make the system unreliable had to be solved.

15. Sources:

Documents:

Files in NOL's Structures Division

NOLTR 62-33, Report on the Design, Development and Test Results of Mud Agitator Mk 1 and Mod 1, dated 28 February 1962.

## RXD Event Description

1. Title: Development of Material for Optimum Compatibility with Electrolytes Used in Electrochemical Timing Devices (#83)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Delayed Rising, Sterilization

4. Element: Clock Delay Mk 21, Sterilizer Mk 10

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event consisted of the formulation of an acid-resistant paint for coating the interior of electrolytic timers and the selection of a special neoprene rubber compound as a gasket and separator material for use in electrochemical devices.

b. Relationship to Contemporary Science and Technology:

At the time of this event, the electroplating process upon which the electrolytic sterilizers SD-4 and SD-10 depended was being adversely affected by contaminants in the electrolyte. This event solved a disruptive situation and significantly improved the reliability of the electrolytic sterilizers and timing devices.

c. Relationship to Succeeding Development or to System Performance:

The use of this event in the form of a highly reliable timer greatly improved system performance. By means of this device, a minefield can be made harmless beyond a selected date so that it no longer restricts movement or requires sweeping, Reliability is of paramount importance; if the system has been contaminated, the time may be prolonged and the minefield may in fact be dangerous when it is presumed to be safe.

6. Type of RXD Event: Exploratory Development

Prepared By: L.E. Kissinger, NOL Date: 4 Mar 66

7. Key Personnel:

S.J. Black, Engineer, Weapons Mechanism Division, Underwater Ordnance Department, NOL. Responsible for the electrolytic sterilizer SD-4.

L.E. Kissinger, Engineer, Weapons Mechanism Division, Underwater Ordnance Department, NOL. Responsible for the electrolytic sterilizer SD-10.

I. Silver, Chemistry Research Department, NOL. Developed a new varnish which would not contaminate an electrolyte.

Dr. A.M. Moos, Patterson, Moos Company. Developed the neoprene rubber formulation.

H.C. Lieb, Patterson, Moos Company. Worked with Dr. Moos.

Dr. A.V. Lindstrom, Rutgers University. Identified the contaminants in the DS-4 electrolyte.

Dr. P.A. van der Meulen, Rutgers University. Worked with Dr. Lindstrom.

8. Date of Event:

a. Termination: 1953

b. Initiation: 1953

9. Duration: Six months

10. Organization:

a. 1. Naval Ordnance Laboratory, White Oak

2. Underwater Ordnance Department

3. Weapons Mechanism Division

4. Chemistry Division

10. Organization: - Continued

b. 1. Leesona Corporation

2. Patterson, Moos Company

c. Rutgers University

11. Organization Type:

a. Government Laboratory

b. Profit Laboratory, Industrial

c. Nonprofit Laboratory, University Operated

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) in-house funds and Navy funds under Contracts Nord 10292 and 14075.

b. Duration- Six months

c. Amount- Estimated $50,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

The feasibility of using electrochemical deposition as the basis for a timing system was already established and NOL eagerly applied this concept in the form of a highly reliable timer to sterilize or dud a mine after the elapse of a preset period of time after planting.

b. Previous Activity:

Various plastics are used in electrochemical timing devices as gaskets, insultators, and containers of the electrolyte. In addition to other essential properties, the plastics that come in contact with the electrolyte must meet

13. System Interface Activity: - Continued

the following requirements: They must not deteriorate, they must restrict transmission of oxygen (from surrounding air into the cell) and water vapor (out of the cell) to a minimum; and they must not contaminate the electrolyte with substances that would interfere with the electrolytic action. Materials that satisfy the first two requirements can be identifed in the technical literature for plastics. The problem of electrolyte containination, however, is a very subtle one. It is required careful study at NOL and by other organizations under NOL contracts. S.J. Black and L.E. Kissinger, the principal engineers working on the electrolytic sterilizers SD-4 and SD-10 at NOL, recognized that the electroplating process upon which these two devices depended was being adversely affected by contaminants in the electrolyte. Contamination appeared to be entering the SD-4 electrolyte from a varnish used on the interior of the cell; the source of contamination in the electrolytic element of the SD-10 appeared to be the gaskets. Under NOL Study Contract Nord 14075, Rutgers University was able to identify the contaminants in the SD-4 electrolyte. Concurrently, NOL's Chemistry Division developed a new varnish which did not contaminate the electrolyte and also had desirably low gas-transmission coefficients. Patterson, Moos Company, working under NOL Contract Nord 10292, found through a series of tests that a neoprene rubber formulation with certain curing agents produced satisfactory gaskets to seal the electrolyte. The combined efforts of NOL, Patterson, Moos Company and Rutgers and, by developing new materials, eliminating them from the electrolytic system.

14. RXD Event Circumstances: None

15. Sources:

Documents:

Joseph Parker and Irving Silver, Investigation of Protective Coatings for use in Mine Sterilizing Unit SD-4, NAVORD Report 2645, 13 Jan 1953.

Patterson, Moos Company status reports under Contract Nord 10292 (1948-1949).

Rutgers University status reports and final report under Contract Nord 14075 (1953-1957).

## RXD Event Description

1. Title: Development of Superior Antifouling Paint for Prevention of Marine Growths on Mine Cases (#100)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mine Case

4. Element: Mechanism Compartments Mk 1 and Mk 2; Explosive Sections Mk 1 and Mk 2

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the development of a new antifouling paint for use on moored mine cases.

b. Relationship to Contemporary Science and Technology:

At the time of this event, the antifouling agents used in paint to prevent marine growths on mine cases were effective for less than six months. The active life of the agents in the new paint was in excess of one year. The paint is identified as Copperpac 9134 Type 1.

c. Relationship to Succeeding Development or to System Performance:

After field tests demonstrated the superiority of the new paint, it was adopted for general use on all moored mines.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

Sigmund Miller, Chemist, Marine Paint Group, University of Miami. Formulated new poisons for incorporation into a paint system.

Prepared By: I.C. Henschen, NOL Date: 22 Feb 66

7. Key Personnel:

C. W. Blum, President, Dolphin Paint and Varnish Company, Cooperated with Miller in the development of an antifouling paint.

W. F. Warren, Project Engineer, Mine and Depth Charge Division, NOL. Responsible for improving the underwater endurance of mines Mark 56 and Mark 57. Conducted field tests of the paint.

W. M. Taylor, Senior Representative, NOL. Acted as liason between paint developers and mine designers.

M. J. Prebilic, Project Engineer, Mine and Depth Charge Division, NOL. Worked with Warren in the field tests.

8. Date of Event:

a. Termination: 1956

b. Initiation: 1955

9. Duration: Approximately two months

10. Organization:

a. 1. Naval Ordnance Laboratory

2. Underwater Ordnance Department

3. Mine and Depth Charge Division

b. 1. University of Miami

2. Marine Paint Group

c. Dolphin Paint and Varnish Company

11. Organization Type:

a. Government Laboratory

b. Nonprofit Laboratory, University Operated

c. Profit Laboratory, Industrial

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds

b. Duration- Approximately two months

c. Amount- Estimated $75,000

d. An additional period of two years was required for field tests.

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

After the superiority of the new paint was proved, it was incorporated into the protective coating specifications for the mine cases for Mines Mk 55, 56, 57 and Mk 10.

b. Previous Activity:

In 1955 an endurance minefield was established at NOL's test facility at Ft. Lauderdale to evaluate various protective coating systems then in use on moored mines. Within six months it became apparent the BUSHIPS Vinyl Antifouling Paint, MIL-P-16189, would not prevent marine fouling for the desired period of one year. Prior to NOL's participation in this event, Sigmund Miller, a chemist on the staff of the University of Miami, and C. W. Blum, president of the Dolphin Paint and Varnish Company, had worked together in an attempt to develop an improved antifouling paint for marine use. By 1955 they were confident that their new formulation was ready for practical application and they so advised W. M. Taylor who was NOL's senior representative at its field test

13. System Interface Activity: - Continued

facility at Ft. Lauderdale. Taylor relayed this information to mine designers at NOL, White Oak. W. F. Warren and M. J. Prebilic, working to improve the underwater endurance of the mines Mk 56 and Mk 57, tried the new paint in a series of tests off Ft. Lauderdale, and found it to be an effective and enduring inhibiter of marine growth.

14. RXD Event Circumstances:

Marine fouling has the effect of increasing the frontal area of the mine case, the drag coefficient of the case, and the weight of the case. All of these factors contribute to an undesirable increase in dip (vertical displacement) of the buoyant mine case in water currents. The resulting position of the mine, therefore, is not that originally intended. If allowed to grow uninhibited, fouling can so overburden a mine case as to depress it too far below the surface. No direct savings in cost resulted from this event. However, since the effectiveness of the mine could be increased in its later life through lower dip (vertical displacement due to water current), an indirect saving can be noted. As originally tested by NOL, the paint had the experimental nomenclature Dolphinite X1?65. This was later changed to Dolphinite 9134 Antifouling Paint, and finally to COPPERPAC 9134 Type 1. Because the formulation is known only to Miller and Blum, the paint is purchased by the Navy as a proprietary item. The active agent in the paint is cupreous oxide, a well established inhibiter of marine growth, and the concentration of this agent is high as compared to other paints that employ it. The unique feature of this particular paint is the binder that allows the copper ions to leach out at a sufficiently fast rate to be effective but not so fast as to be short lived.

15. Sources:

Persons Interviewed:

I. C. Henschen, NOL

M. W. Crawford, NOL

W. Tyalor, NOL

15. Sources: - Continued

Documents:

NCL #TN 4108, "Water Impact Tests of Dolphinite X1265," dated October 1957.

NOL #TN 3802, "Antifoulding Paint," dated December 1956.

## RXD Event Description

1. Title: Development of a Technique for Nondestructive Determination of Structural Strength by Use of Differential Hydrostatic Pressure Test (#102)

2. System: Mines Mk 56 and Mk 57

3. Subsystem: Mine Case

4. Element: Mechanism compartments Mk 1 and Mk 2; Explosive Sections Mk 1 and Mk 2

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the development of a differential pressure technique, an original, nondestructive method for determining the incipient buckling pressure of thin shells subjected to external pressure. The salient feature of the technique is the filling of the internal volume of the shell with a compressible fluid, such as water, to control the magnitude and rate of shell deformation. The incipient buckling pressure is detected by noting the point at which the difference in internal and external pressure becomes constant.

b. Relationship to Contemporary Science and Technology:

At the time of this event, extra pressure hulls were required when destructive testing was necessary or the tests had to be conducted late in the program using hardware that had been subjected to other necessary but undamaging environments. This nondestructive technique aided the designer by permitting mine cases to be tested early in the development. The technique also allowed a statistically significant number of mine cases to be tested, which established quite accurately the proper depth capabilities of a specific type of case. This technique was reported in NOLR 1154; dated 28 May 1951. It was later presented at the 1952 fall meeting of the American Society of Mechanical Engineers.

c. Relationship to Succeeding Development or to System Performance:

A number of spin-off test methods have resulted from the basic principle.

Prepared By: R. F. Mead Date: 28 February 66

5. Technical Significance:- Continued

The technique has saved many dollars worth of experimental hardware because it is nondestructive.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

J. C. New, chief, Mechanical Evaluation Division, NOL. Originated the technique.

H. F. Koch, mechanical engineer, Mechanical Evaluation Division, NOL. Assisted in developing the technique into an effective evaluation tool.

J. E. Salmon, mechanical engineer, Mechanical Evaluation Division, NOL. Assisted in the development.

8. Date of Event:

a. Termination: 1951

b. Initiation: 1950

9. Duration: Approximately one year

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Technical Evaluation Department

c. Mechanical Evaluation Division

d. Pressure Section

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Foundational Research (FR-1-51) funds.

12. Financial Support:- Continued

b. Duration- Approximately one year

c. Amount- Estimated $15,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event has been applied to all pressure-hull development programs at NOL from 1951 to the present time. No subsequent method of testing for structural integrity has superseded this useful technique. It specifically has been used in the development of the pressure hulls for the mines Mark 56 and Mark 57.

b. Previous Activity:

This event was motivated by the need to establish the strength of pressure hulls without damaging these costly items before obtaining other important data during the developing programs. The cost of these pressure hulls ranged from $3,000 each to $20,000 or more.

14. RXD Event Circumstances:

At the time of this event,special research programs could be financed by Foundational Research funds. Unfortunately, such efforts are now tied to specific weapon developments; if the objective is not quickly attained, the sponsoring project may not profit from the results.

15. Sources:

Person Interviewed:

John E. Salmon, NOL.

Documents:

J. C. New, A Nondestructive Method for Detecting the Incipient Buckling Pressures of Thin-Walled Shells, NORL 1154, dated 28 May 1951.

15. Sources:- Continued

J. C. New, A Nondestructive Differential-Pressure Test for Thin Shells, ASME - Applied Mechanics Division Paper No. 52-F-10, dated 7 March 1952.

RXD Event Description

1. Title: Conception and Demonstration of Controlled Collapse Hydrostatic Pressure Test (103)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mine Case

4. Element: Mechanism Compartments Mk 1 and Mk 2, Explosive Sections Mk 1 and Mk 2

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the conception and demonstration of the controlled collapse test. It was a natural outgrowth of the differential pressure test. The technique involves filling the interior of the case with water, subjecting the case to external pressure, and monitoring the expelled water. Some water is discharged as the pressure mounts and the structure is compressed. Accelerated water discharge is an indication of deformation of the pressure hull.

b. Relationship to Contemporary Science and Technology:

The test also provides an accurate measure of the buoyancy loss of the case as a function of depth (applied pressure). The technique was published as a standard test in Naval Ordnance Laboratory Technical Note 1441, Revision 1, 10 August 1954.

c. Relationship to Succeeding Development or to System Performance:

This test was specifically used in the development of the mine Mark 56. The technique has been frequently used on mines which have been developed since its inauguration. It has proved to be a useful complement to the differential pressure test.

6. Type of RXD Event: Exploratory Development

Prepared By: R. F. Mead, X-658 Date: 2 Mar 66

7. Key Personnel:

J. E. Salmon, mechanical engineer, Mechanical Evaluation Division, NOL. Originated the technique and developed it into a useful evaluation tool.

8. Date of Event:

a. Termination: 1951

b. Initiation: 1951

9. Duration: Two months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Technical Evaluation Department

c. Mechanical Evaluation Division

d. Pressure Section

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source-Navy (Bureau of Ordnance) funds

b. Duration-Two months

c. Amount-$2,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This evaluation technique has been applied to most pressure-hull development programs at NOL from 1951 to the present time.

13. System Interface Activity:-Continued

b. Previous Activity:

The event was motivated by a need to complement the information obtained from the nondestructive differential pressure test but without regressing to the total collapse method of testing. Mine cases are too expensive ($3,000 to $20,000 each, depending on the quantity) to permit indiscriminate destruction testing.

14. RXD Event Circumstances:

It is necessary that designers be able to identify and possibly improve the weakest part of a structure which must survive external pressure; this technique permits such a determination. The basis for the technique was known and it required only directed effort to establish the procedures and confirm its usefulness.

15. Sources:

Persons Interviewed:

J. E. Salmon, NOL

Documents:

NOL TN 1441 Rev.1, "Tests Conducted in the Ordnance Environmental Laboratory," 10 August 1954.

## RXD Event Description

1. Title: Development of Technique for Simulation of Mine Response to Ships' Magnetic Fields (128)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: a. Overall

   b. Actuation (Magnetic Influence)

4. Element: a. Test and Evaluation (Techniques)

   b. Firing Mechanism Mk 26, Total Field Magnetic, Magnetometer

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event concerns the development of a technique for simulating mine response to ships' magnetic fields.

   b. Relationship to Contemporary Science and Technology:

When a new mine is released to the fleet, the latter must be fully advised of its capabilities. In particular, the fleet must be provided with data regarding the mine's likely response to each of a wide variety of ships under a broad range of circumstances. Previously, the data were obtained by time-consuming and expensive methods using actual mechanisms in laboratory-created magnetic fields. This tedious method often delayed the provision of actuation data. This event demonstrated that it is possible to substitute a computer program, operating on data representing ship signatures, for the previous and laborious method that involved generating the ship's magnetic field by a coil system and requiring that the firing mechanism react to it. This represents a broadening of mine response studies by reason that emphasis was shifted from slow laboratory methods to rapid computer programming.

Prepared By: S. A. Jashemski, 495-7369 Date: 15 Mar 66

5. Technical Significance:-Continued

c. Relationship to Succeeding Development or to System Performance:

With this technique, it is now possible to determine the response of a mine to a large library of ship signatures at a very fast rate. This event promises a potential breakthrough in that it now may be possible to evaluate a new mine, or any proposed redesign of an existing mine, in a fraction of the time previously needed. This means mine-response data for fleet use will become available more quickly and in greater detail than heretofore possible.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

Stanley A. Jashemski, physicist, Electrical Evaluation Division, NOL. Acted as group leader for this work on the simulation of the mines Mark 56 and Mark 57.

Richard D. Caminiti, electrical engineer, Electrical Evaluation Division, NOL. Supervised the gathering of the significant data.

William H. Wertman, mathematician, NOL. Supervised the mathematical processing of the data and helped in the gathering of the data and in the writing of the computer program.

8. Date of Event:

a. Termination: 1966

b. Initiation: 1964

9. Duration: Eighteen months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Evaluation Department

c. Electrical Evaluation Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source-Navy (Bureau of Naval Weapons) funds under three task assignments:

(1) CM12-MI000/212-1/F008-01-28 (Mine Analyses, Studies and Tests); (2) CM12-MI000/212-1/F108-08-10 (Mine Mechanism Investigations); and (3) R361-00000/212-1/F008-98-12 Problem 015 (Computer Simulation Mine Response).

b. Duration-Eighteen months

c. Amount-Estimated $60,000

d. Of the estimated amount, $25,000 was for the first task assignment, $15,000 for the second, and $20,000 for the third.

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

Success with a similar computer simulation of two other mines was the prime influence in trying this approach on the Mines Mk 56 and Mk 57.

b. Previous Activity:

This event was motivated by the need to provide detailed mine-response data for fleet use as rapidly as possible at NOL. S. A. Jashemski had been working on new techniques for magnetic simulation for some years

13. System Interface Activity:

before this event and had succeeded ir demonstrating the feasibility of a similar type of simulation for two other mines. His associates in the work on the simulation of the mines Mark 56 and Mark 57 were Caminiti and Wertman. An analysis of the total field magnetic influence firing mechanism Mark 26 for the mines Mark 56 and Mark 57 was performed which permitted a description of the properties of the mechanism in terms of a computer program. An array of numbers is used to describe the ship's magnetic field. When this data is fed into an IBM 7090 computer, the latter computes the response of the mine to this field and thus determines whether the mine fired and, if it did, the location of the fire in relation to the target position. The problem was complicated by the fact that the mine has a nonlinear response. This tedious method often delayed the provision of actuation data.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

Stanley A. Jashemski, NOL

## RXD Event Description

1. Title: Development of a Reusable, Bomblike Vehicle for Launching from High Altitudes To Achieve Extreme Speeds for Flight-Gear Experimentation (#129)

2. System: Mines Mk 56 and Mk 57

3. Subsystem:

   a. Overall

   b. Flight Gear

4. Element:

   a. Evaluation Technique

   b. Parachute Pack Mk 28 and Release Mechanism Mk 23

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event involved the develcpment of a technique to test flight equipment at speeds not attainable by means of available aircraft. A free-fall test vehicle was developed to attain velocities of 1,100 feet per second when dropped from altitudes above 30,000 feet from aircraft flying no faster than 300 knots.

   b. Relationship to Contemporary Science and Technology:

This event constitutes a method of testing weapon parachutes and associated flight gear at velocities approaching the speed of sound from aircraft incapable of approaching this speed. It also provides a safe method of testing flight equipment before endangering an aircraft with actual high-speed tests.

Prepared By: James D. Byrd, Jr. NOL(WO) Date: 5 Mar 66

5. Technical Significance:- Continued

c. Relationship to Succeeding Development or to System Performance:

An immediate result of this event was the redesign of the parachute for the Mine Mk 56 to eliminate a weak method of construction. Also, this event permitted a determination of the maximum speed the flight equipment could be used in service.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

James D. Byrd, Jr., engineer, Underwater Technical Evaluation Department, NOL. Conceived the idea of using a low-drag, high-speed test vehicle as a free-fall test platform for measuring flight-gear performance.

William P. Ludtke, aerospace engineer, Ballistics Department, NOL. Acted as a consultant to Byrd and advised him of the ballistic characteristics that were needed to achieve a high-speed test vehicle.

8. Date of Event:

a. Termination: 1959

b. Initiation: 1958

9. Duration: One year

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. 1. Underwater Technical Evaluation Department

2. Mechanical Evaluation Division

10. Organization:- Continued

c. 1. Ballistics Department

2. Ballistic Design and Operations Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Navy funds under BuWeps Task Assignment 445-864/46028/410040: Development of High Speed Flight Gear, Procurement and Evaluation.

b. Duration - one year

c. Amount - Estimated $30,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in determining the maximum speed that mine Mark 56 flight equipment would withstand before failure; the findings resulted in a redesign of the method for constructing the parachute. This event introduced a safe means of testing experimental parachutes for weapons. It was successfully used in testing a new generation of high-speed flight gear for the entire family of postwar air-laid mines and will be used for future weapons as well.

b. Previous Activity:

This event was motivated by the need to devise a means that would permit the gathering of data on the performance of the flight equipment at near-sonic speeds. It was realized by the Mechanical Evaluation Division that aircraft were not available to test the flight equipment for the mine Mark 56 at the speeds cited by the operational requirements. It was also appreciated that wind tunnels would not be useful in the determination of flight-gear performance, which requires exposure to high speed for a

13. System Interface Activity:- Continued

sustained period of time. Byrd conceived the idea of testing the complete flight equipment assembly by attaching it to a streamlined free-falling test vehicle of the same mass as the mine. The vehicle is allowed to drop from a high altitude to attain the desired velocity before the parachute is deployed. By knowing the ballistic parameters of the test vehicle, an internal timer can be set to deploy the parachute at a time equivalent to the desired test velocity.

14. RXD Event Circumstances: None

15. Sources:

Person Interviewed:

James D. Byrd, Jr., NOL

Document:

Conf. NOL letter to BuWeps Serial 0918 dated 4 April 1961, Subj: Parachute Packs Mk. 34-0, 36-0 and 28-1 for Mines; recommendation for release of.

# RXD Event Description

1. Title: Development of Torsional Pendulum Method of Determining Moment of Inertia of Assembled Mine (#130)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Overall

4. Element: Test and Evaluation (Techniques)

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the adaptation of the physical principle of the torsion pendulum to the measurement of the moment of inertia of an assembled mine by observing the period of the rotating mass.

b. Relationship to Contemporary Science and Technology:

At the time of this event, applicable contemporary systems of measurement, including those characterized as compound pendulum and trifilar pendulum systems, were time-consuming and costly. This event provided a faster and less expensive method measurement.

c. Relationship to Succeeding Development or to System Performance:

This event improved system performance by speeding up the test and evaluation techniques.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

W.F. Warren, Mechanical Engineer, Mine and Depth Charge Division, Naval Ordnance Laboratory. Responsible for making moment-of-inertia measurements for the Mine Mk 56. Designed the first working model of the torsional pendulum adaptation.

Prepared By: J.W. Dulancy, NOL Date: 2 Mar 66

7. Key Personnel: - Continued

C.C. Vogt, Deputy Chief, Mine and Depth Charge Division, and Warren's Supervisor. Proposed the adaptation of a torsional pendulum.

8. Date of Event:

a. Termination: 1955

b. Initiation: 1955

9. Duration: One month

10. Organization:

a. Naval Ordnance Laboratory

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy Bureau of Ordnance funds

b. Duration- One month

c. Amount- Estimated $10,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

After the successful demonstration of the torsional pendulum system for the measurement of moment inertia of the assembled mine Mk 56, it was used for measuring many other weapons, including other mines, depth bombs, and missiles.

13. System Interface Activity: - Continued

b. Previous Activity:

The suspension systems used to hold weapons aboard aircraft, and indeed the aircraft themselves, are severely strained by loads imposed by the weapons during catapult launching, maneuvering and arrested landing. These loads can be reduced in magnitude by restricting the moment of inertia of each individual weapon. By Military Specification MIL-A-8591, maximum values are cited for each weight category; for example, for 2,000-pound stores such as mine Mk 55, the transverse moment of inertia must not exceed 360 slug feet squared. Because the final design must be compatible with this restriction, each design considered during development had to be tested to determine its actual values. Warren considered the systems in use at the time of this event to be too time-consuming and tedious. He studied alternative possibilities and, at the suggestion of his supervisor, Vogt, he adapted the torsional pendulum to serve this purpose.

14. RXD Event Circumstances:

The use of the torsional pendulum for moment-of-inertia measurement resulted in substantial savings of time and money for each unit tested.

15. Sources:

Person Interviewed:

J.W. Dulaney, NOL

# RXD Event Description

1. Title: Feasibility Demonstration of Isolator To Eliminate Galvanic Couple and Reduce Fatigue of Mooring Rope (74)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mooring (Mine Mk 56)

4. Element: Wire Rope Assembly Mk 1

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the conception and demonstration of a flexible isolator for naval mine use that provides electrical separation between the different metals used for a mine case and its mooring cable, thereby preventing a destructive galvanic couple at their interface. It also improves the mechanical endurance of the mooring cable by providing physical support at the point of maximum flexure.

b. Relationship to Contemporary Science and Technology:

The total field magnetic influence firing system used by the mines Mark 56 and Mark 57 requires that all material near it be nonmagnetic. This applies to the mine case and to its internal components, and even to that part of the mooring rope immediately adjacent to the case. Phosphor bronze wire rope is sufficiently nonmagnetic to satisfy this requirement, but,when in sea water, will contribute to a damaging galvanic couple if connected directly to the steel alloy case. Furthermore, because it is relativity weak, the phosphor bronze rope cannot withstand high-amplitude flexing at the terminal end of the cable. This event provided an isolator to electrically separate the case and the cable, and because it encircled and supported the latter it also reduced local fatigue.

c. Relationship to Succeeding Development or to System Performance:

The use of this isolator improved the general system performance by helping to meet the operational requirement for a service life of one year for each of these moored mines.

Prepared By: I C. Henschen, 495-7242 Date: 22 Mar 66

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

I. C. Henschen, mechanical engineer, Cases and Anchors Branch, NOL. Proposed the isolator idea when phosphor bronze was selected for use as the nonmagnetic portion of the mooring rope.

W. F. Warren, mechanical engineer, NOL. Tested isolator prototypes as part of NOL's endurance minefield located off its facility at Fort Lauderdale.

8. Date of Event:

a. Termination: 1957

b. Initiation: 1955

9. Duration: One month for the conception and design of the isolator, plus an additional two years for confirming life tests.

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Weapons Structure Division

d. Cases and Anchors Branch

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source-Navy (Bureau of Ordnance) funds

b. Duration-Twenty-five months: funds were available as required

c. Amount-Estimated less than $10,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

The isolator produced by this event was successful in reducing the galvanic couple between the mooring cable and the mine case, and it also improved the fatigue resistance of the mooring system. However, the material first used for this isolator was found to fail after a few months' use. For this reason the material itself had to be improved before the full benefit of the isolator could be realized. This was accomplished.

b. Previous Activity:

This event was motivated by the requirement of the firing system used by the mines that all material near it be nonmagnetic.

14. RXD Event Circumstances:

It is impossible to cite cost savings directly attributable to this event. However, because of the improvements contributed by the isolator, the life of the phosphor bronze part of the mooring cable was more than doubled. The endurance of this part now matches the underwater life of the steel alloy case.

15. Sources:

Persons Interviewed:

M. W. Crawford, NOL

I. C. Henschen, NOL

H. E. Mathews, NOL

Documents:

NOL TN 3805, "Mooring System Endurance," November 1956.

NOL TN 3819, "Mooring System Endurance," January 1957.

## RXD Event Description

1. Title: Concept Established for Inert-Loaded Drill Mine (118)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Drill Mine

4. Element: Overall System

5. Technical Significance:

a. Orgin, Technical Activity and Outcome:

This event demonstrated that a recoverable drill mine, realistic in every respect except for its inert load, could be provided to the fleet for use as a training weapon.

b. Relationship to Contemporary Science and Technology:

At the time of this event, special drill mine recovery floats were attached to the end of the mine. This of course added length and weight to the mine and affected its dynamic behavior. The drill mines with external float recovery systems were generally restricted to lesser planting depths than the service mine. Because the mines Mark 56 and Mark 57 use the entire stowage envelopes now available to them aboard their launching vehicles, any system that increases the overall size of either mine is no longer useful. For example, the service mine Mark 56 is 114.8 inches long--the maximum permitted for weapons or stores to be carried at 2,000-pound bomb stations aboard aircraft; any increase in mine length would result in incompatibility with the plane. This event provided a drill mine functionally, dimensionally, and dynamically identical to the service mine. It can be handled, planted, and fired in the same manner as its service mine counterpart. It provides devices for visually indicating actuation and for facilitating recovery without the need for divers.

c. Relationship to Succeeding Development or to System Performance:

The drill mines Mark 56 and Mark 57, which utilize this concept, provide an excellent device for training crews in mine assembly, submarine or aircraft planting, mine sweeping, and minefield analysis.

Prepared By: S. Wolf, 495-7224 Date: 4 Mar 66

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

D. M. Leslie, Project Manager, Drill Mine Section, NOL. Responsible for the drill mines Mk 56 and Mk 57.

R. D. Mattingly, supervisor of several engineers in Leslie's Drill Mine Section. He and Leslie cooperatively established the concept for the drill mine XA-4 (later to become the drill mine Mark 56). He directed the work of design engineers who produced the first working model.

8. Date of Event:

a. Termination: 1954

b. Initiation: 1954

9. Duration: Approximately eight months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

d. Drill Mine Section

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source-Navy (Bureau of Ordnance) funds

b. Duration-Eight months; funds available as required

c. Amount-Estimated $150,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event established the basic concept for the drill mine Mark 56. The subsequent development of specific recovery systems and actuation signal systems were based upon this event. The development of the drill mine Mark 57 was founded on the concepts proposed during this event.

b. Previous Activity:

This event was motivated by the need for a new drill system, incorporated within the service mine outline. Initiative for this event resided in the Mine and Depth Charge Division of NOL.

14. RXD Event Circumstances:

The drill mines Mark 56 and Mark 57 permit realistic planting operations using aircraft and submarines, respectively; they respond to target influences and activate in the same manner as their service equivalents; but, instead of firing a warhead, they send visual signals to the surface to indicate that they have been "fired" and are ready for recovery. The final operation (recovery) is made easy by the fact that the drill system in each anchor unlocks (but does not unleash) the submerged, moored case and allows the latter to surface; the costly anchors are then pulled aboard by means of their own mooring cable.

15. Sources:

Documents:

Naval Ordnance Report 3689, A Review of the Drill Mine Problem, December 1953.

NOL TN 2980, 'Drill Mine XA-4; Proposed Design for," February 1955.

## RXD Event Description

1. Title: Feasibility Demonstration of Use of Vermiculite as Filler Material for Inert Simulation of Explosive Load in Mine Warhead (119)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Drill Mine

4. Element: Explosive Sections Mk 1 and Mk 2

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event established the feasibility of using a cement and vermiculite aggregate to produce an inert filler material for drill versions of mines and depth charges that closely simulates the physical properties of the high explosive used in their service counterparts.

   b. Relationship to Contemporary Science and Technology:

At the time of this event, the material used for the inert loading of various weapons was plaster. For different densities, varying proportions of water were used. Often much of the water did not enter into the chemical reaction but remained as free water. When exposed to cold temperatures during storage or while carried aboard aircraft operating at high altitudes, this water would freeze and often rupture the case. The compressive strength of the plaster-loaded case was also decreased by the presence of excess water, thus robbing the structure of necessary support. With the cement and vermiculite aggregate it was found that the desired densities could be obtained while maintaining sufficient compressive strength. The inert load remained unaffected by extreme temperatures. The mixing and loading process proved to be simple and relatively inexpensive. This work is described in NOLM 10233.

   c. Relationship to Succeeding Development or to System Performance:

As a consequence of this event, the use of the cement and vermiculite inert load was adopted for all inert loaded mines, depth charges and similar weapons. This increased mine resistance to extreme weather conditions.

Prepared By: S. Wolf, 495-7224 Date: 1 Mar 66

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

John C. Goff, mechanical engineer, Mine and Depth Charge Division, NOL. Conceived the process and demonstrated its feasibility.

8. Date of Event:

a. Termination: 1949

b. Initiation: 1949

9. Duration: Six months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

d. Cases and Anchors Section

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source-Navy (Bureau of Ordnance) funds

b. Duration-Six months

c. Amount-$2,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

The vermiculite-cement inert loading was used for simulating the explosive in minesMark 56 and Mark 57 explosive compartments during

13. System Interface Activity:-Continued

design tests of the overall weapons. Later it was used for the drill mines Mark 56 and Mark 57. Over the years it has been adopted as the standard inert loading composition for new and stockpile mines and depth charges. Information regarding this inert loading process was disseminated to many Navy design facilities and loading plants where extensive use has been made in a variety of applications.

b. Previous Activity:

The technical initiative for this work resided with the Mine and Depth Charge Division of NOL, in the person of Goff. At the time of the event he was a mechanical engineer working on the design of anchors and associated mechanisms for a variety of mines. Although he was not responsible for inert loading considerations, he learned of the problems attendant upon the use of plaster and, without other instigation, sought and found a solution.

14. RXD Event Circumstances:

Although it is not possible to quote any cost savings resulting from the use of this loading procedure, the savings were substantial and will continue. For example, special storage of inert loaded cases is no longer required because of freezing problems, and the loss or damage to mine cases due to freezing has been eliminated.

15. Sources:

Persons Interviewed:

John C. Goff, Goddard Space Flight Center

C. C. Vogt, NOL

Document:

NOLM 10233, 'Proposed Inert Load For Underwater Ordnance,' dated 24 Aug 1949.

# RXD Event Description

1. Title: Feasibility Demonstration of a Pyrotechnic Signal-and-Float System that Ignites upon Arrival at Surface (122)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Drill Mine

4. Element: Signal Float Mk 16

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the invention of a mechanism that delays ignition of the pyrotechnic signal (used to indicate that a submerged drill mine has been actuated) until this buoyant signal has been released by the mine and had time to surface. When the drill mine is "fired" by a target vessel, the signal-and-float system is unlocked and allowed to ascend. When near the surface, the signal recognizes the fall-off of hydrostatic pressure and fires a stab primer in the signal to start the pyrotechnic display. At the time of this event, signals were ignited by a time delay that had to be set sufficiently long to allow the signal to surface. For a mining exercise wherein individual drill mines were moored at various depths, signals from the shallower mines would surface and be subjected to drift for the period of time before ignition.

b. Relationship to Contemporary Science and Technology:

This event constituted a departure from the drill mine pyrotechnic signal state of the art by providing surface-sensing ignition delay. The principles of operation and details of design are set forth in the disclosure for U. S. Patent No. 3,086,464.

c. Relationship to Succeeding Development or to System Performance:

This device, as well as other features of the signal float, permitted automatic use of a standardized pyrotechnic signal throughout the full operating depth of the service mine without an unacceptable delay between the time of mine actuation and the surface display. The latter now occurs as soon

Prepared By: S. Wolf, 495-7224 Date: 21 Feb 66

5. Technical Significance:-Continued

as the signal arrives at the surface. The new minimum delay system is necessary to ascertain more accurately which mine in a field was activated by what ship and to determine the distance from the actuating ship to the particular mine. This event increases usefulness of the drill mines to the fleet because prompt and accurate assessments of a mine's ability to respond to a target--or to ignore a countermeasure--are now possible.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

C. W. Dovell, project engineer, Drill Mine Section, NOL. Invented the device.

V. G. Costley, project engineer, Drill Mine Section, NOL. Responsible for several design changes that improved the performance of the device.

8. Date of Event:

a. Termination: 1957

b. Initiation: 1957

9. Duration: Five months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

d. Drill Mine Section

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source-Navy (Bureau of Ordnance) funds

b. Duration-Five months

c. Amount-Estimated $30,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

The signal ignition system was incorporated into the signal-and-float system when its feasibility was demonstrated.

b. Previous Activity:

At the onset of the drill mine Mark 57 development it was recognized that a high-performance mine-actuation signal could and should be designed for the drill mine. Sufficient space was therefore provided in the drill section of the drill mine so that a signal system with a brilliant display and other desirable features could be used. With this self-generated incentive, attention was directed toward, among other features, an automatic surface-sensing signal-ignition system.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

D. M. Leslie, NOL

C. W. Dovel, NOL

V. G. Costley, NOL

15. Sources:-Continued

Documents:

Disclosure for U. S. Patent No. 3086464, issued 19 July 1960.

Naval Ordnance Laboratory Technical Note 3704.

## RXD Event Description

1. Title: Development of an Explosive Primer Mixture with Improved Stability and Reliability. (Report No. 88.)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Explosive (Flight Gear)

4. Element: Primer Mk 101

5. Technical Significance:

a. This event involved the development of a stable and reliable primer mixture.

b. At the time of this event, the standard base for primer mixtures was mercury fulminate, but this explosive material was unstable when temperature and humidity cycled. The mercury fulminate would decompose and give off free mercury. This event established an optimum mixture, consisting of basic lead trinitroresorcinate, barium nitrate, antimony sulphide, and telracene for percussion primers. The mixture had superior stability, endurance, and compatibility features.

c. The use of this mixture in the primer Mark 101 Model 3 has increased the shelf life of the thermal battery Mark 51 Model 2, which powers the delayed-opening parachute system for the mine Mark 56 and other air-launched mines.

6. Type of RXD Event: Research

7. Key Technical Personnel:

George Graff, explosives expert, NOL. Supervised and directed this development.

R. T. Skelton, NOL. Assisted Graff in the development.

E. F. Ward, NOL. Assisted Graff in the development.

Prepared By: V. J. Menichelli, 495-7739 Date: 25 Mar 66

8. Date of Event:

a. Termination: 1949

d. Initiation: 1944

9. Duration: Approximately five years.

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Research Department

c. Explosives Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Navy (Bureau of Ordnance) funds.

b. Approximately five years.

c. Estimated $250,000.

13. System Interface Activities:

a. Since the development of this primer mixture, it has been adopted throughout the Department of Defense and by industry. The mix was also found ideal for use in stab detonators. Since the latter must be more powerful than primers, the energy of the basic mix was increased by adding lead azide.

b. Explosive mixes that degrade with the passage of time or that decompose when subjected to extreme temperatures are hazardous and unreliable. Their frequent replacement to insure their freshness is expensive. For these reasons, NOL was determined to study the nature of likely ingredients, and identify those that were the most stable and compatible with other materials. Many mixes were found to be too powerful for this rather

13. System Interface Activities:-Continued

critical use and would result in "blow-back" wherein the energy would not propagate forward into the explosive train but would reverse and waste itself by venting toward the firing pin. Various candidate materials were carefully and exhaustively examined at NOL.

14. RXD Event Circumstances: None.

15. Information Sources:

Persons:

I. Kabik, NOL.

E. Ward, NOL.

J. Davis, NOL.

RXD Event Description

1. Title: Development of a Variable-Drag Fairing for Mines Carried Externally by High-Speed Aircraft (Report No. 106)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Flight Gear (Mine Mk 56)

4. Element: Mine Fairing Kit Mk 21

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the development of a fairing that reduces the inherent drag of a mine when the mine is carried at an external weapon station aboard an aircraft but automatically increases this drag when the mine is released. The mine fairing consists of a forward section and an aft fin assembly. The forward section includes a hemispherical nose, a cylindrical shroud, and a retracting mechanism. The nose may be either in an extended position (projecting beyond the shroud) or a retracted position (hidden within the shroud). In the extended position, the assembly provides a low-drag configuration for the mine; when retracted, the nose lies within the shroud to provide a blunt, high-drag configuration. The retracting mechanism is a mechanically operated, spring-loaded, ball-lock system. It locks the nose in the extended position until it is triggered by an arming wire at the moment of launch; the spring provides the energy to shift the nose into the shroud, whereupon it is relocked. The fin assembly is attached to the cover of the parachute pack located on the tail of the mine; the fins provide additional stability to the mine during the unretarded portion of its fall. The fin assembly remains with the mine until the cover of the pack is ejected immediately prior to deployment of the parachute. The nose section remains with the mine until it is wiped off by impact with the water.

b. Relationship to Contemporary Science and Technology:

At the time of this event, mine fairing concepts involved a simple hemispherical nose that was fixed in place, plus an aft fairing which, when the mine was released from the aircraft, would pivot into the wind stream a number of drag flaps to stabilize the weapon and reduce its velocity. The aft assembly was mechanically complex and had to be extremely rugged to withstand the aerodynamic loads imposed upon the several flaps. It was difficult to insure that all of the flaps would pivot into their working position, and the

Prepared By: A. C. Peterson, 495-7248 Date: 21 Feb 66

5. Technical Significance:-Continued

refusal of any one or more would upset the trajectory of the mine. The system was complicated, heavy, unreliable and expensive; it was never placed in production. This event made it possible to carry mines at exposed stations aboard aircraft without severely limiting the latter's speed and range and to drop these faired mines using the same ballistic tables employed for their unfaired counterparts carried in the bomb bays.

c. Relationship to Succeeding Development or to System Performance:

This event improved system performance in two ways. First, it significantly increased the range of the aircraft by decreasing the drag while the mine is being transported. Second, by increasing the drag when the mine is dropped, it causes the mine to fall with the same trajectory as that of its unfaired counterpart in the bomb bay. Because the variable-drag fairing is simple, lightweight, reliable, and economical, it also contributed to the overall system performance.

6. Type of RXD Event: Exploratory Development

7. Key Technical Personnel:

A. C. Peterson, Project Manager, Mine Retardative Equipment, NOL. Directed the work leading to this event.

R. G. Schuetzler, aerospace engineer, Flight Control Section, Ballistics Design and Operations Division, NOL. Conceived the event, with Ludtke and McNelia.

W. P. Ludtke, aerospace engineer, Flight Control Section, Ballistics Design and Operations Division, NOL. Conceived the event, with Schuetzler and McNelia.

J. F. McNelia, aerospace engineer, Flight Control Section, Ballistics Design and Operations Division, NOL. Conceived the event, with Schuetzler and Ludtke.

8. Date of Event:

a. Termination: 1962

b. Initiation: 1962

9. Duration: Approximately five months.

10. Organization:

    a. (1) Naval Ordnance Laboratory, White Oak

       (2) Ballistics Department

       (3) Ballistics Design and Operations Division

       (4) Flight Control Section

    b. (1) University of Maryland

       (2) Wind Tunnel Facility

    c. David W. Taylor Model Basin

    d. Naval Aerospace Recovery Facility

11. Organization Type:

    a. Government Laboratory

    b. Nonprofit Laboratory, University Operated

    c. Government Laboratory

    d. Government Laboratory

12. Financial Support:

    a. Navy (Bureau of Naval Weapons) funds

    b. Approximately five months; funds were available as required.

    c. Estimated $60,000.

13. System Interface Activity:

a. This event was used in the entire family of air-launched mines, including the mines Mark 52, Mark 55, Mark 56, and Mark 57.

b. The mine Mark 56 is capable of aircraft carriage either within a bomb bay or at exposed stations outside the fuselage. When carried outside, the otherwise blunt shape of the mine must be faired to reduce the drag imposed upon the aircraft. As soon as the mine is released, this fairing becomes a handicap because a highly streamlined mine falls much faster than its unfaired counterpart; standard bombing tables used by the bombardier to calculate launch points for unfaired assemblies cannot be used for faired units. To avoid the need for a special table for the latter, NOL decided to design a fairing that would transform itself into a high-drag configuration when released from the aircraft. Because this event required extensive model and full-scale testing to confirm its feasibility, NOL ran tests in the subsonic wind tunnel of the University of Maryland, than in the transonic tunnel at the David Taylor Model Basin, and finally conducted full-scale tests at the Naval Aerospace Recovery Facility.

14. RXD Event Circumstances: None

15. Information Sources:

Persons interviewed:

A. C. Peterson, NOL.

R. G. Schuetzler, NOL.

W. P. Ludtke, NOL.

J. F. McNelia, NOL.

## RXD Event Description

1. Title: Feasibility Demonstrated for Drill Mine, upon Actuation, To Release Buoyant Mine Case to Surface and Permit Recovery of Entire System (Report #120)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Drill Mine

4. Element: Recovery System

5. Technical Significance:

a. This event involved the invention of a system to release the locked anchor of a moored drill mine so that its buoyant case can surface and thereby permit the recovery of both the case and anchor. In the drill mine Mk 56, the locked reel in the anchor is released by pneumatically powered pistons which act in sequence against a locking gear and a locking pawl. The mechanism is initiated by a special drill-mine timer which actuates in explosive valve, thus releasing high-pressure air to the pistons. The reel is thus freed to turn, and the case can surface. In the drill mine Mark 57, the same function is effected by unlocking the cable gripper with an explosive driver.

b. At the time of this event, recovery of moored drill mines was accomplished by either attaching a recovery float to the mine or by having a loose bight in the mooring line which, when it released, allowed the mine case to surface. Both of these methods appreciably altered the characteristics of the mine and limited its planting depth. This event provided a simpler, more reliable, and more realistic recovery operation. The anchor release mechanism for the drill mine Mark 56 is described in the disclosure for U. S. Patent No. 2,961,957. The anchor-release mechanism for the drill mine Mark 57 is described in OP 2718.

c. This event improved system performance by providing a more realistic drill mine, more valuable for training in the assembly and use of the service mines.

6. Type of Event: Exploratory Development.

Prepared By: S. Wolf and G. Costley, 495-7224 Date: 8 Mar 66

7. Key Technical Personnel:

D. M. Leslie, project manager, Drill Mine Section, NOL. Responsible for the drill mines Mark 56 and Mark 57.

S. Wolf, mechanical engineer, Drill Mine Section, NOL. Conceived the idea for the mechanical release system for the drill mine Mark 56. Cited by the patent as the inventor.

C. W. Dovell, mechanical engineer, Drill Mine Section, NOL. Designed a similar anchor-release system for the drill mine Mark 57 and demonstrated the feasibility of recovery of the mine by using the surfaced mine case.

8. Date of Event:

a. Termination: 1956

b. Initiation: 1956

9. Duration: Four months.

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

d. Drill Mine Section

11. Organization Type: Government Laboratory

12. Financial Support:

a. Navy (Bureau of Ordnance) funds.

b. Four months.

c. Estimated $45,000.

13. System Interface Activity:

a. When it was established by this event that it was practical to unlock the mine case and allow it to surface and permit recovery of both itself and its anchor, the detail design parameters for the release systems were established. This event is now used in both drill mines Mark 56 and Mark 57.

b. Early in the drill-mine Mark 56 and Mark 57 development programs, it was recognized that a departure from previous drill-mine-recovery methods was imperative. It was noted that both mines had enough cable to allow their mine cases to surface. In the normal mooring operation, the payout of mooring cable is arrested by a mechanism in the anchor when the buoyant case (heretofore married to and on the bottom with its anchor for the duration of the delay rising period) reaches its preset moored depth. To cause a drill-mine case to surface for recovery, the arresting mechanism must be unlocked. When a preset timer initiates this action a desired number of hours or days after the plant, the buoyant mine surfaces for recovery and the anchor is retrieved by means of its own mooring rope.

14. RXD Event Circumstances: None.

15. Sources:

Persons Interviewed:

D. M. Leslie, NOL.

C. W. Dovell, NOL.

Document:

Disclosure for U. S. Patent No. 2,961,957.

## RXD Event Description

1. Title: Invention of a Drill Mine Float To Accommodate Variety of Pyrotechnic Signals and Permit Separate Stowage of Pyrotechnic Elements (123)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Drill Mine

4. Element: Signal Float Mk 16; and Signals, Smoke and Illumination, Marine, Mk 55, Mk 69, and Mk 70

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the invention of a drill mine signal float that can accommodate several different pyrotechnic flares. The float, housed within the submerged drill mine, is released when the mine is actuated. It then rises to the surface whereupon a mechanism in the float initiates the flare. The float provides sufficient space to use large and brilliant flares and it effectively seals the floats from seawater.

b. Relationship to Contemporary Science and Technology:

At the time of this event, it was necessary to design an individual float or signal housing for each new pyrotechnic flare used in drill mines. Perhaps a new firing device would also have to be designed to accommodate a different flare. This event provided a universal float system. Its design and operating principles are described in the disclosure for U. S. Patent No. 3,086,464.

c. Relationship to Succeeding Development or to System Performance:

The successful operation of the drill mine concept was greatly facilitated by this event. The accommodation of several signals by a universal float was much more economical than was possible with individual floats. Also, with the concept of separate flare and float, flares that have exceeded their shelf life in storage could be discarded without scrapping the float.

6. Type of RXD Event: Exploratory Development

Prepared By: V. G. Costley Date: 1 Mar 66

7. Key Personnel:

V. G. Costley, Project Engineer, Drill Mine Section, NOL. Responsible for the conception and design of the float.

D. Bosco, Project Engineer for the signals Mark 55, 69, and 70, NOL. Produced a design for the three signals that were compatible with Costley's single float.

8. Date of Event:

a. Termination: 1957

b. Initiation: 1957

9. Duration: Two months

10. Organization:

a. 1. Naval Ordnance Laboratory, White Oak

2. Underwater Ordnance Department

3. Mine and Depth Charge Division

4. Drill Mine Section

b. 1. Chemistry Research Department

2. Chemical Engineering Division

3. Pryotechnic Signal Section

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source-Navy (Bureau of Ordnance) funds

b. Duration-Two months

c. Amount-Estimated $25,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was incorporated into the drill mine Mark 56. At that time, only one type of signal flare was available. Later, during development of the drill mine Mark 57, two other types of signal flares were developed and incorporated into the float. This float-signal combination had the particular advantage of permitting separate stowage and handling of the pyrotechnic flare and the inert float assembly. This feature offered economy of magazine storage space. Also, with this concept of separate flare and float, flares that have exceeded their shelf life in storage can be discarded without scrapping the float.

b. Previous Activity:

Early in the drill mine Mark 57 development, it was recognized that a variety of pyrotechnic displays would be required to distinguish between the several types of mines that could be planted in a mixed minefield. A variety of signals would also provide a means to distinguish between mines of the same type that had been outfitted with different firing systems or different settings for sensitivity, moored depth, and the like. The potential cost savings to the Navy motivated Costley to try to design one float that was compatible with several signals. He believed that it was feasible to avoid the use of unique floats for each of several types of signals and was granted a patent for his universal float system.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

V. G. Costley, NOL

D. Bosco, NOL

15. Sources:-Continued

Documents:

Files in Drill Mine Section, Underwater Ordnance Department, NOL

Disclosure for U. S. Patent 3,086,464

RXD Event Description

1. Title: Invention of an Integral Watertight Explosive Fitting and Electrical Cable (Report No. 124)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Drill Mine (Drill Mine Mk 56)

4. Element: Explosive Fitting Mk 7

5. Technical Significance:

a. This event involved the invention of an integral watertight explosive fitting, cable and electrical connector, which is essential to the successful operation of drill-mine signals because no water may be permitted to touch the mine after the electrical cable from the mine to the signal is purposefully cut as part of the drill sequence. The explosive element is connected to the cable and then sealed against water pressure by an epoxy potting compound. At the other mine end of the cable, a similar connection and seal is made with an electrical connector. The joint between this connector and its mating receptacle is sealed by an O-ring. The potting compound also acts as a water-stop after the explosive fitting is fired. The water-stop prevents water from seeping back through the cable and into the mine instrument compartment.

b. At the time of this event, the techniques available to prevent water from traveling inside an electrical cable depended on multiple interfaces properly assembled in the field. If a cable were to admit water into a mine case, the expensive weapon would probably be lost and the drill exercise would have to be repeated to be meaningful. This event, by providing a fully integrated and self-blocking cable, eliminated this vulnerability to operator error. The sealed connector is described in the disclosure for U.S. Patent No. 2,991,441.

c. This event simplified assembly of the explosive fitting into the drill mine by eliminating a connection between the explosive element and the cable. It also eliminated the need for a watertight housing for the explosive element; and it provided a water-stop integral with the connector and explosive element rather than by a special joint in the cable.

6. Type of RXD Event: Exploratory Development.

Prepared By: F. E. Butler, 495-7785 Date: 3 Mar 66

7. Key Technical Personnel:

F. E. Butler, mechanical engineer, Drill Mine Section, NOL. Co-inventor of explosive fitting and cable combination.

S. Wolf, mechanical engineer, Drill Mine Section, NOL. Co-inventor of the item.

8. Date of Event:

a. Termination: 1956

b. Initiation: 1956

9. Duration: Five months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

d. Drill Mine Section

11. Organization Type: Government Laboratory

12. Financial Support:

a. Navy (Bureau of Ordnance)

b. Five months

c. Estimated $8,000.

13. System Interface Activities:

a. This event was used in the drill mine Mark 56 and later in various

13. System Interface Activities:-Continued

other drill mines. Adaptations are now being used for the entire family of drill mines.

b. A drill mine Mark 56 costs several thousand dollars. The entire mine can be recovered after drill exercises are concluded, but it is imperative that the watertight integrity of the mine is maintained throughout its underwater use. This integrity is threatened when the drill cable from the mine case is cut as part of the system sequence. NOL was thus motivated to design a watertight explosive fitting and cable combination.

14. RXD Event Circumstances: None

15. Information Sources:

Persons:

F. E. Butler, NOL.

S. Wolf, NOL.

Documents:

Disclosure for U. S. Patent No. 2,991,441, issued July 4, 1961.

TN-2980, 1 February 1955.

TM-3725, 15 November 1956.

Project Note Book #96-5314.

NOL letter to BuWeps, FS:DML:lpk 8550 Ser. 02822, dated 23 Dec 60.

# RXD Event Description

1. Title: Invention of Pneumatic-Powered Core Sampler To Obtain Ocean-Bottom Sediment Specimens (#136)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Overall

4. Element: Test and Evaluation (Equipment)

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This involved the invention of a pneumatic coring mechanism capable of obtaining undisturbed cores of ocean bottoms composed of clay, sand and/or soft coral.

   b. Relationship to Contemporary Science and Technology:

At the time of this event, corers used a free-falling dead weight as the driving mechanism. The corers worked successfully in mud but not in sand. This invention advanced the state of the art to the recovery of cores in sandy and hard sediments and added a new method for the collection of ocean-bottom sediments. The details of the device are given in the disclosure for U. S. Patent No. 3,139,945.

   c. Relationship to Succeeding Development or to System Performance:

This event improved system performance by aiding in the study of mine burial.

6. Type of RXD Event: Exploratory Development

Prepared By: Julius Castigliola  Date: 4 Mar 66

7. Key Personnel:

Julius Castigliola, Oceanographer, NOL. Co-inventor of the pneumatic corer.

B. Del Re, Technician, NOL. Co-inventor of the pneumatic corer.

8. Date of Event:

a. Termination: 1962

b. Initiation: 1962

9. Duration: Four months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Evaluation Department

c. Mechanical Evaluation Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy funds under Bureau of Weapons Task Number RUME-2E-000 P.A. 032.

b. Duration- Four months

c. Amount- Estimated $5,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

The pneumatic corer was used to obtain cores of the ocean bottom during field testing of explosive embedment anchors. The corer was subsequently used in studying the burial of a variety of mines in soft bottoms. The invention has had extensive and varied use beyond its original purpose. For example, it has been used by contractors to the Beach Erosion Board to locate submerged sources of sand for the purpose of rebuilding eroding beaches. The invention is now used by the Alpine Geophysical Company, Marine Advisors, Inc., and others involved in building piers, making scientific surveys, evaluating the economic importance of sediments, and similar undertakings.

b. Previous Activity:

This event occurred during experiments with several types of explosive embedment anchors which were being considered for use with the mines Mk 56 and Mk 57. To rate the holding power of these novel anchors, it was necessary to obtain undisturbed cores of representative clay, sand, coral, and rock bottoms. The need to obtain cores in sand resulted in an inquiry into a means for improving the driving mechanism of the corer. Explosive, electrical, and pneumatic means were considered; the pneumatic means was chosen because of its high energy, simplicity, and ease of manufacture.

14. RXD Event Circumstances:

The Director of Construction, U.S. Naval Station, San Juan, Puerto Rico, has predicted that the use of the corer will save $10,000 per day for a period of two weeks in estimating a cost contract for the dredging of a channel at Roosevelt Roads.

15. Sources:

Persons Interviewed:

Bradley, NOL.

15. Sources: - Continued

B. Del Re, NOL.

Documents:

Disclosure for Patent No. 3,139,945.

NOLTR 63-117, Field Tests To Determine the Holding Capacity of Explosive Embedment Anchors, dated 10 July 1963.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

C. W. Dovell, mechanical engineer, Drill Mine Section, NOL. Invented the device.

V. G. Costley, mechanical engineer, Drill Mine Section, NOL. Responsible for several design changes that improved the performance of the device.

8. Date of Event:

a. Termination: 1957

b. Initiation: 1957

9. Duration: Two months

10. Organization:

a. Naval Ordnance Laboratory, (NOTS)

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

d. Drill Mine Section

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source-Navy (Bureau of Ordnance) funds

b. Duration-Two months

c. Amount-Estimated $15,000

## RXD Event Description

1. Title: Invention of an Explosive Bolt with Dual Function as Release Device and Flooding Valve (125)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Drill Mine (Drill Mine Mk 57)

4. Element: Explosive Fitting Mk 10

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event involved the invention of an explosive bolt that is used not only to secure and subsequently release a float from a mine case, but also to open a port to admit seawater into the chamber that houses the float.

   b. Relationship to Contemporary Science and Technology:

At the time of this event, signal floats were rather violently propelled out of the mine chamber. This invention provided a "soft" release; its chief advantages are improved safety (no shrapnel hazard) and lower structural loads on the float and the chamber cover. The invention constitutes an extension of the normal single function of an explosive bolt, which is to provide a mechanical thrust. The principles of operation and design details of this invention are given in the disclosure for U.S. Patent No. 3,094,928.

   c. Relationship to Succeeding Development or to System Performance:

This invention improved system performance by increasing the reliability of the drill mines. The float is subjected to seawater pressure for a much shorter time (seconds vs. days or weeks), galvanic corrosion is eliminated, the seals on the compartment are redundant to the seals on the float, and blocking of the float by silt and sea growth within the chamber is prohibited. The system resulting from this event is less complex, less expensive, and more reliable.

Prepared By: V. G. Costiey, 495-7785 Date: 1 Mar 66

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in the drill mine Mark 57 and later in other drill applications.

b. Previous Activity:

This event was motivated by the realization that signal float release and expulsion could be facilitated and made more reliable if both functions could be performed by a single device. The added valving function was needed to permit seawater flooding of the drill mine float compartment so that the float could be released. Because the water pressure on the float compartment cover is much greater than the spring force available to remove it, the pressure must be equalized by combining the valving function and the release function in a single explosive bolt.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

C.W. Dovell, NOL

V.G. Costley, NOL

Documents:

Disclosure for U.S. Patent No. 3,094,928, 25 June 1963.

NOL TN 3704.

## RXD Event Description

1. Title: Feasibility Demonstration of Use of Solid-Film Lubricants for Clock and Counter Mechanism (#85)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Arming and Safing, Actuation

4. Element: Clock Delay Mk 19, Actuation Counter Mk 10

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event consisted of the feasibility demonstration of the use of solid-film lubricants on timing and counting mechanisms, particularly on the escapements of these mechanisms.

b. Relationship to Contemporary Science and Technology:

Liquid lubricants applied to timing mechanisms tend to spread, dry up, or become contaminated in a few years, thus causing the mechanisms to refuse to start or otherwise perform unreliably. Consequently, they must be disassembled, cleaned, reoiled, and reassembled at considerable cost. This event constitutes an extension of the state of the art of lubrication in the special field of low-energy devices.

c. Relationship to Succeeding Development or to System Performance:

The use of solid-film lubrication has improved the reliability of clock and counter mechanisms used in the mines Mk 56, Mk 57, and other underwater naval mines, and has eliminated the cost of reconditioning them.

6. Type of RXD Event: Exploratory Development

Prepared By: R.J. Lyon (NOL) Date: 23 Feb 66

7. Key Personnel:

J.W. Talcott, Supervisor, Timing Devices Branch, Naval Ordnance Laboratory (NOL). Directed the work that led to this event.

R.J. Lyon, Mechanical Engineer, Timing Devices Branch, NOL. Under Talcott's supervision, initiated and carried out the work.

R.L. Lorenz, Chief Engineer, General Time Laboratory, General Time Corporation. Cooperated with Lyon in the attempt to use solid-film lubricants on clock escapements.

S.P. Zbell, Seth Thomas Clocks. Supervised the manufacture of the escapements.

L.J. Shirley, Mechanical Engineer, Timing Devices Branch, NOL. Assisted Lyon during the intensive testing phase.

8. Date of Event:

a. Termination: 1956

b. Initiation: 1953

9. Duration: Six months

10. Organization:

a. 1. Naval Ordnance Laboratory, White Oak

2. Underwater Ordnance Department

3. Weapon Mechanisms Division

4. Timing Devices Branch

b. 1. General Time Corporation

2. General Time Laboratory

3. Seth Thomas Clocks

10. Organizacion: - Continued

4. Engineering and Design Department

c. Seth Thomas Clocks is a division of General Time Corporation.

11. Organization Type:

a. Government Laboratory

b. Profit Laboratory, Industrial

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) in-house funds and Navy funds under Contract No. NOrd 11216.

b. Duration- Six months

c. Amount- Estimated $15,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

Solid-film lubrication was investigated by NOL for possible use on a variety of timing and counter mechanisms in addition to the actuation counter used as a test vehicle for early experimentation.

b. Previous Activity:

In 1955 when NOL and General Time Laboratory (GTL), under contract, were developing a new actuation counter for mine use, they considered the use of a solid-film clock escapement. The need for cleaning and reoiling clock-type mechanisms was well known. Lyon and Lorenz of NOL and GTL, respectively, believed that a dry-film lubricant would offer a distinct advantage of long shelf life; accordingly, the manufacturer of the escapements, Seth Thomas Clocks, was asked to provide some prototypes using the Electrofilm dry-film lubrication. S.P. Sbell of Seth Thomas had the experimental escapements made and submitted them to Lorenz. Preliminary tests were made by GTL, followed by more intensive testing by NOL. Several types of solid-film lubricants had been investigated at GTL and NOL, including Teflon coating, gold plating, electrolyzing, Molykote

13. System Interface Activity: - Continued

and Electrofilm. Electrofilm proved to be the most durable and effective.

14. RXD Event Circumstances: None

15. Sources:

Documents:

Naval Ordnance Laboratory Notebooks No. 80-3956 and No. 96-4856 by R.J. Lyon.

RXD Event Description

1. Title: Development of Antifouling Compound for Prevention of Marine Growths on Mooring Wire Rope (#77)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mooring

4. Element: Anchors Mk 56 and Mk 57

5. Technical Significance:

a. This event involved the development of a soft antifouling compound to prevent marine growths on cables used for mooring the mines Mark 56 and Mark 57.

b. At the time of this event, compounds used to protect underwater cables were based primarily on petroleum greases. These compounds were not effective in an antifouling capacity, and they would wash off in a short time. Corrosion of the underlying cable would begin soon after planting of the mine. The antifouling cable compound that constitutes this event reduced the rate of loss of the cable's galvanized coating and at the same time retarded the formation of marine growths. The specification MIL-C-21947 describes the formulation and manufacture of this new material.

c. The introduction of this antifouling compound permitted the use of smaller cable sizes without any sacrifice in mooring endurance. The use of small-diameter cables for mine moorings is highly desirable because their reduced drag results in less mine-case "dip" in ocean currents. Moreover, the poisons incorporated into the compound prevent the accumulation of marine growth which would otherwise increase the frontal area of the cable and, therefore, its drag.

6. Type of RXD Event: Exploratory Development

7. Key Technical Personnel:

W. F. Warren, mechanical engineer, Mine and Depth Charge Division, NOL. Responsible for the endurance testing of mine-mooring systems.

Prepared By: I. C. Henschen, 495-7242 Date: 21 Feb 66

7. Key Technical Personnel:-Continued

J. E. Cowling, NRL. Developed a specific formulation for a marine poison.

8. Date of Event:

a. Termination: 1956

b. Initiation: 1954

9. Duration: Approximately two years.

10. Organization:

a. (1) Naval Ordnance Laboratory, White Oak

(2) Underwater Ordnance Department

(3) Mine and Depth Charge Division

b. Naval Research Laboratory, Washington

11. Organization Type: Government Laboratory

12. Financial Support:

a. Navy (Bureau of Ordnance) funds

b. Approximately two years

c. Estimated $60,000

13. System Interface Activities:

a. This event was used by mine designers in several ways: without changing the diameter of a mooring cable, they could increase its underwater endurance by coating it with this compound; by using a smaller diameter cable, they could reduce the dip of a moored case without sacrificing its endurance, and they could accommodate a greater length of smaller diameter cable within a given

13. System Interface Activities:-Continued

anchor volume. The compound is now specified for use on both anchors Mark 56 and Mark 57, plus naval equipment that must remain moored for long periods of time.

b. In 1952, NOL established an experimental minefield off Ft. Lauderdale for the purpose of studying and improving the endurance of moored mines. Part of this effort included an examination of the effectiveness of available greases and poisons to protect underwater cables against corrosion and marine growths. W. F. Warren was aware of the inadequacies of petroleum-based compounds and asked the advice of experts in marine poisons at NRL. As a result, a new and suitable compound was formulated and tested.

14. RXD Event Circumstances: None

15. Information Sources:

J. E. Cowling, NRL.

I. C. Henschen, NOL.

# RXD Event Description

1. Title: Invention of Electrochemical Timing Device (#80)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem:

   a. Delayed rising

   b. Sterilization

4. Element:

   a. Clock delay Mk 21

   b. Sterilizer Mk 10

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event concerns the invention of a new type of electrochemical timer using a spring-loaded, dual anode system for markedly improving the accuracy of such devices which were used to sterilize naval mines at the expiration of a preset period of time.

   b. Relationship to Contemporary Science and Technology:

At the time of this event, electrolytic timers, first introduced by the British, were essentially closed phenolic cells containing copper sulfate as the electrolyte, with copper cathodes and anodes. When a small direct current was applied to the cell, copper plating occurred at the cathode at the expense of the anode. In the original British and early U.S. designs, the anode was configured as a diaphragm; a spring-loaded plunger pressed against its outer or dry face. The electrical deposition continued at a rate dependent upon the current until the diaphragm was sufficiently weakened to allow it to be pierced by the plunger. Movement of the plunger was used to close switches and thereby sterilize the mine. Moreover, the improved timers have a shelf life of 10 years

Prepared By: L. J. Lofthus, NOL (WO) Date: 16 Feb 66

5. Technical Singificance:- Continued

as compared with 2 years for the previous electrolytic timers. The device is fully described in the disclosure for U.S. Patent No. 2,526,670.

c. Relationship to Succeeding Development or to System Performance:

This event together with related events resulted in timing devices with much greater accuracy and thus improved the general system performance.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

R. C. Duncan, Technical Director, NOL. Supervised the effort leading to this invention.

J. B. Turlay, Chief Mechanical Engineer, Underwater Ordnance Department, NOL. Co-inventor of the device.

E. F. Ellison, Project Engineer, Mine and Depth Charge Division, NOL. Co-inventor of the device.

L. E. Kissinger, Project Engineer, Mine and Depth Charge Division, NOL. Co-inventor of the device. Later introduced the concept of a dual anode.

K. N. Boley, Mechanical Engineer, Mine and Depth Charge Division, NOL. Assisted Kissinger in the dual anode concept.

S. J. Black, Mechanical Engineer, Mine and Depth Charge Division, NOL. Worked with Boley and Kissinger on the dual anode concept.

8. Date of Event:

a. Termination: 1946

b. Initiation: 1943

9. Duration: Approximately three years

10. Organization:

    a. 1. Naval Ordnance Laboratory, White Oak

       2. Underwater Ordnance Department

       3. Mine and Depth Charge Division

    b. Admiralty Mining Establishment

11. Organization: Government Laboratory

12. Financial Support:

    a. Source- Navy (Bureau of Ordnance) funds

    b. Duration- Approximately three years

    c. Amount- Estimated $30,000

13. System Interface Activity:

    a. Contemporary and Succeeding Activity:

Electrodeposition is used as the timing control for the sterilizer Mark 10 which is used to dud and flood the moored mines Mark 56 and Mark 57 and dud the bottom mines Mark 52 and Mark 55. The same system is used in the clock delay Mark 21 to delay the mooring of the Mark 56 and Mark 57 and delay the arming of the Mark 52 and Mark 55. A further application of this type of timer has been provided as the clock delay Mark 22 to perform both arming and sterilization functions for stockpile mines, World War II vintage.

    b. Previous Activity:

Samples and disclosures of the British electrolytic switch were made available to NOL in 1943. The reliability of this device was very impressive--much better than the reliability of mechanical and electromechanical clock mechanisms. However, the timing variations inherent in the British design were considerable. To more fully capitalize on the use of this type of device as a mine sterilizer and as a means for delaying the mooring and arming of mines,

13. System Interface Activity:- Continued

it was essential that the timing spread be reduced.

14. RXD Event Circumstances:

During World War II, the United States and Great Britain cooperated very closely on mutual problems of mine design and mine countermeasures. NOL and its counterpart Laboratory in England, the Admiralty Mining Establishment, exchanged technical information on many matters, and scientists and engineers from both organizations became very familiar with developments and advances made by their opposite group. When NOL learned of the British work on electrolytic timers, drawings and data were requested and were quickly provided. Innovations accomplished by NOL were, in turn, made available to the British.

15. Sources:

Persons Interviewed:

S. J. Black, NOL

L. E. Kissinger, NOL

Documents:

NAVORD Report 6080.

## RXD Event Description

1. Title: Development of a Device To Determine and Record Attitude of Mine on Ocean Bottom During Delayed-Rising Period (#81)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Delayed Rising

4. Element: Test and Evaluation (equipment)

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the conception of an extremely simple, yet fully capable device for sensing and recording the physical orientation of the mines Mark 56 and Mark 57 while on the ocean bottom during their delayed-rising phase. The device consists essentially of a small container partially filled with a resin which is kept fluid by a means of a catalytic delay for a number of hours but which then hardens. The relationship of its "frozen" surface plane with the axis of its its container—hence, with the axis of the mine—thus establishes the attitude of the latter with respect to the vertical.

b. Relationship to Contemporary Science and Technology:

At the time of this event, various means were available for determining a mine's attitude on the ocean bottom. A pendulum system could be used, but existing instruments were costly, shock sensitive, and complex. Divers could observe or photograph the mine, but a reference plane might be difficult to establish and their use would not be feasible in deep water. This event provided a simple, capable, very reliable device completely immune to water impact and costing only a few dollars.

c. Relationship to Succeeding Development or to System Performance:

Use of this device during the development and evaluation of the mines Mark 56 and Mark 57 permitted a fuller understanding of problems relating to case-and-anchor release. Because the release operation had been found to be somewhat attitude sensitive, the device was useful in establishing the critical angle beyond which release was unlikely and in assessing design changes intended to relieve the problem.

Prepared By: L. J. Lofthus Date: 2 Mar 66

6. Type of RXD Event: Exploration Development

7. Key Technical Personnel:

K. F. Cannon, mechanical engineer, Test Department, NOL Conceived and developed the simple attitude recorder.

H. B. Adkinson, chemical engineer, Cases and Anchor Section, Mine and Depth Charge Division, NOL. Assisted Cannon in the department.

8. Date of Event:

a. Termination: 1954

b. Initiation: 1954

9. Duration: One week

10. Organization:

a. 1. Naval Ordnance Laboratory, White Oak (NOL)

2. Test Department

b. 1. Underwater Ordnance Department

2. Mine and Depth Charge Division

3. Cases and Anchor Section

11. Orginization Type: Government Laboratory

12. Financial Support:

a. Source-Navy (Bureau of Ordnance) funds.

b. Duration-One week

c. Amount-Estimated $2,000.

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

The cases of both mines Mark 56 and Mark 57 are secured to their anchors by means of bell cranks which are gagged by pins. The latter are explosively removed at the expiration of the mine's delay rising period. Separation of the buoyant case from its anchor is handicapped if the case-anchor axis is considerably off vertical. It was discovered during development that, if the mine struck the bottom at a severe angle, it could topple onto its side and not recover. If this happened, separation was unlikely. As a result, design refinements were introduced to relieve this problem. Now, when the locking pin is removed, a spring force causes the mine to move away from the anchor, and separation is achieved without dependence upon buoyancy alone, which tends to pivot the case and cramp the bell cranks.

b. Previous Activity:

Attitude-sensing devices are usually intended for use in situations where the position of the platform is subject to shifting, and they must be able to present a record of these variations over a period of time. As such, they usually are complex and costly mechanisms, often vulnerable to shock. Because the mines Mark 56 and Mk 57 soon seat themselves firmly on the ocean bottom and seldom undergo changes in position, a low-cost device which could sense this single position—after striking the water at 200 feet per second—was needed. This event produced such a device.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

S.E. West, NOL

D.B. Fraser, NOL

L.J. Lofthus, NOL

# RXD Event Description

1. Title: Study of Candidate Electrolytes for Electrochemical Timing Devices (# 82)

2. System: Mines Mk 56 and Mk 57

3. Subsystem:

   a. Delayed rising

   b. Sterilization

4. Element:

   a. Clock delay Mk 21

   b. Sterilizer Mk 10

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event concerns a study of various candidate electrolytes for use in electrochemical timing devices and the selection of lead fluoborate as the optimum electrolyte. Electrolytes and anode materials to be used in such devices must have certain properties and maintain them throughout a long shelf life and over a wide temperature range. The anode material must not dissolve spontaneously, without application of current, when immersed in the electrolyte; it must deplate at a rate proportional to the applied current; and the deplated material must be disposed of, as by deposition upon a cathode, in a manner which will not interfere with the functioning of the timing device.

   b. Relationship to Contemporary Science and Technology:

At the time of this event, contemporary devices, using copper sulfate, had timing inaccuracies as great as ± 30%, and these devices were incapable of achieving an overall delay of one year. Many electrolytes were described

Prepared By: L. E. Kissinger Date: 21 Feb 66

5. Technical Significance:- Continued

in the electroplating literature, but relatively few have all the properties required for use in electrolytic timing devices. This event and other work in the field significantly advanced the state of the art of electrolytic timers.

c. Relationship to Succeeding Development or to System Performance:

This event resulted in the establishment of a particular electrochemical system which permitted the construction of timing devices capable of providing preset time delays ranging from a minimum 5 minutes to more than one year and reliable throughout a temperature range of $-20^{o}F$ to $100^{o}F$.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

L. E. Kissinger, chemist, Mine and Depth Charge Division, NOL. Responsible for this study. Established that lead fluoborate was functionally equal to the lead perchlorate used by the British in similar electrolytic timers.

A. M. Moos, Patterson, Moos and Company. Confirmed Kissinger's findings and established the preferred concentrations.

J. C. Delfino, Patterson, Moos and Company. Assisted Moos in this event.

H. C. Lieb, Patterson, Moos and Company. Assisted Moos in this event.

8. Date of Event:

a. Termination: 1948

b. Initiation: 1948

9. Duration: Six (6) months

10. Organization:

a. (1) Naval Ordnance Laboratory, White Oak

(2) Underwater Ordnance Department

10. Organization:- Continued

(3) Weapon Mechanisms Division

b. (1) Leesona Corporation

(2) Patterson, Moos and Company (Division of Leesona Corporation)

11. Organization Type:

a. Government Laboratory

b. Profit Laboratory, Industrial

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) in-house funds and funds under Contract Numbers NORD 10292 and NORD 13293.

b. Duration- Approximately six months

c. Amount- Estimated $10,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

Multiswitch timers using this electrolyte were developed in various forms to serve as sequential arming clocks and sterilizers for mine applications and as time controls for other ordnance systems, sonobuoys, and meteorological balloons.

b. Previous Activity:

The characteristics desired for the sterilizer Mark 10 regarding minimum and maximum delay time, operating temperature range, and accuracy made it apparent that an electrochemical system superior to any in use at the time was required. NOL was aware of British work in this area but found that the lead perchlorate preferred by the British was not commercially available in the United States. Thus it was necessary for NOL to search for and identify a commercially available electrolyte

13. System Interface Activity:- Continued

that was sufficiently stable for use in a relatively precise timing system and which would maintain its characteristics without change so that a one-year active life after several years on the shelf was possible.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

J. W. Talcott, NOL

L. E. Kissinger, NOL

Documents:

Patterson, Moos and Company status reports submitted under Contracts NORD 10292 and NORD 13293.

RXD Event Description

1. Title: Development of Finishes for Glass Fabrics To Improve Strength of Resin-Glass Bond in Reinforced Plastics (#93)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mine Case (Mine Mk 57)

4. Element: Mechanism Compartment Mk 2, Explosive Section Mk 2

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the development of a new family of finishes to improve the mechanical strength and underwater endurance of glass-fiber composites. The best of these finishes is identified as NOL-24.

b. Relationship to Contemporary Science and Technology:

At the time of this event, state-of-the-art plastic structures were inadequate because of their initially low mechanical strength and because this strength degraded rapidly in a water environment. This event demonstrated that a new generation of high-strength reinforced plastics was possible. Under a broad evaluation program, the new finishes were found to be far superior to state-of-the-art finishes of the time. The original nature and significance of this work are given in the disclosures for Patent Nos. 2,720,470 and 2,776,910.

c. Relationship to Succeeding Development or to System Performance:

The mine case for the mine Mark 57 was required to be nonmagnetic and electrically resistive, and this event improved system performance by contributing to that requirement.

6. Type of RXD Event: Exploratory Development

Prepared By: Dr. P.W. Erickson, NOL Date: 1 Mar 66

7. Key Personnel:

P.W. Erickson, Organic Chemist, Plastics Branch, Chemistry Division, NOL. Conducted the necessary laboratory experiments and contributed ideas which resulted in the new finishes.

I. Silver, Chemist, Plastics Branch, Chemistry Division, NOL. Directed the conduct of the laboratory experiments and also contributed useful ideas.

H.A. Perry, Chief, Plastics Branch, Chemistry Division, NOL. Contributed ideas regarding modes of evaluation and arranged for pilot plant trials at a commercial finishing plant.

8. Date of Event:

a. Termination: 1958

b. Initiation: 1952

9. Duration: Approximately six years

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Engineering Department

c. Chemistry Division

d. Plastics Branch

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance "Standards and Specifications") funds.

b. Duration- Approximately six years

c. Amount- Estimated $100,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in the mine Mk 57. The work at NOL stimulated further research in finishes by private industry within a relatively short time, and as a result of this event a selection of finishes is now commercially available for the production of low-cost, high-strength, water-resistant, reinforced plastic structures. For example, the Dow Corning Corporation learned of NOL's work and eventually developed a large number and variety of finishes which are now commercially available and are used in a broad variety of Department of Defense applications. The Polaris program, in particular, benefited from this work in that excellent finsihes were available when development of its filament-wound cases was undertaken. Fothergill and Harvey in England developed a commercial process for applying the NOL-24 finish to glass cloth, and this cloth has been used by industry as a premium-grade reinforced material. The Plastics Division of Union Carbide Corporation extended NOL's work, and their A-1100, A-174, A-172, Y-2086, and Y-4087 finishes are now widely used by industry and the Department of Defense. This event had two important by-products. One was the development of the NOL ring test method for testing glass roving, No suitable means existed at the time for evaluating finishes for glass roving, the material used for filament-wound reinforced plastics. The ping test method has since become standard for both the Department of Defense and industry; the method has been formalized as AST Test Nos. D22290-64-T, D2291-64-T, and D2344-65-T. The second by-product of this work was the general upgrading of military specifications for reinforced plastics.

b. Previous Activity:

This event was motivated by the need for a nonmagnetic, highly electrically resistive mine case for the mine Mark 57 because of its firing system. The object of NOL's research program was to dramatically upgrade the wet-strength properties of reinforced plastics. A total of 38 different chlorosilanes were investigated as finishes for glass-fiber reinforcements.

14. RXD Event Circumstances: None.

15. Sources:

Documents:

NAVORD Report 2802, Chemical Finishes for Glass Fiber Reinforcement (1953).

NAVORD Report 3811, Universal Type Chemical Finishes for Glass Fibers Used in Reinforced Plastics (1954).

NAVORD Report 3899, Improved Reinforced Plastics with the Universal Type Chemical FinishNOL-24 (1955).

NAVORD Report 4461, Summary Report on NOL-24 Finish on Glass Cloth (1957).

NAVORD Report 5742, A Comparison of NOL-24 Finish with Y-1100 and A-172 Finishes as These Relate to Plastic Laminate Strength Properties (1958).

NAVORD 6058, Evaluation of NOL-24 Treated Low-Dielectric Glass Fabric (1958).

NAVORD 6133, Proposed New Specification Requirements for 181 Style Glass Fabric Reinforced Plastics (1958).

NAVORD Report 6705, Proposed Revision of Specification Requirements for 181 Style Glass Fabric Reinforced Plastic Laminates (1959).

## RXD Event Description

1. Title: Study of Corrosion and Marine Fouling of Stainless-Steel Moored Mines in Contrasting Marine Environments (#101)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mine Case (Mine Mk 56)

4. Element: Mechanism Compartment Mk 1; Explosive Section Mk 1

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the study of complete Mine Mark 56 assemblies under different marine environments to determine whether the metals and protective coatings used in this weapon were fully compatible. The mine case is a weldment of stainless steel Type 205, a new chrome-manganese austenite steel; the mooring cable is a combination of phosphor bronze wire rope and galvanized plow-steel wire rope; the anchor is cast steel; and the antifouling paints and greases used on the mine case and mooring cable, respectively, are cupric oxide poisons held in various vehicles which permit controlled leaching.

b. Relationship to Contemporary Science and Technology:

At the time of this event, the literature contained information regarding the underwater behavior of some of the metals involved in this study, but there was no data concerning the new stainless steel which was developed, not for underwater use but for jet-engine applications, nor the unique combination of metals used in the total assembly, nor the compounds which comprise the antifouling system. This event provided the knowledge previously lacking and advanced the state of the art of the metals under study.

c. Relationship to Succeeding Development or to System Performance:

The findings generated by this event were useful in identifying and devising certain design improvement which lengthened the underwater life of the Mine Mk 56. As a result of these studies in dramatically different ocean environments, it was found, for example, that the zinc coating of the plow-steel rope deteriorated

Prepared By: J. Rosenberg, NOL Date: 2 Mar 66

5. Technical Significance: - Continued

very rapidly near the anchor; sacrificial metal anodes were incorporated to solve this problem. Also, it was found that,wherever the mine case had been welded subsequent to its heat treatment, a carbide precipitation was encountered which accelerated corrosion. Techniques were recommended which restrict the possibility of this occurring in production.

6. Type of RXD Event: Advanced Development

7. Key Personnel:

J. Rosenberg, Electrical Engineer, Mechanical Evaluation Division, NOL. Planned and directed the study.

J. Castigliola, Oceanographer, Mechanical Evaluation Division, NOL. As a specialist in the study of marine sediments, he assisted Rosenberg in the conduct of the study.

R. A. Beuttenmuller, Mechanical Engineer, Environmental Evaluation Department, NOL. Assisted Rosenberg in the conduct of the study, particularly in the area of corrosion mitigation.

J. DePalma, Oceanographer, Inshore Survey Branch, Ocean Survey Division, Naval Oceanographic Office. A specialist in marine fouling, he acted as consultant to the NOL team.

8. Date of Event:

a. Termination: 1963

b. Initiation: 1963

9. Duration: Nine months

10. Organization:

a. 1. Naval Ordnance Laboratory, White Oak

2. Underwater Evaluation Department

3. Mechanical Evaluation Division

4. Environmental Evaluation Department

5. Environment Simulation Division

b. 1. Naval Oceanographic Office

2. Ocean Surveys Division

3. Inshore Survey Branch

11. Organization Type: Government Laboratories

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds

b. Duration- Nine months

c. Amount- Estimated $50,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

The knowledge and testing techniques derived from this study were applied to subsequent underwater weapon development programs.

13. System Interface Activity:

a. Previous Activity:

The new stainless steel alloy Type 205 was sufficiently nonmagnetic and electrically resistive to be suitable for use with the total field magnetic influence firing system. However, little was known about its corrosion characteristics in seawater, particularly when used in combination with various other metals. Lack of this particular knowledge was a principle motivation for this event. NOL was also concerned about the degrading influence of the "oxygen concentration effect" on different surfaces of the same metal. This phenomenon, which is caused by a concentration of free oxygen in one place and a deficiency in an adjacent place, makes the former noble or passive at the expense of the latter, which is depleted and weakened. It was conjectured that marine fouling might contribute to an oxygen imbalance, and it was believed than any susceptibility to this effect would be revealed by the warm-water trials. This phenomenon was not found to be a significant problem. Also, the possibility of galvanic action, as caused by the free copper provided as a poison, was not found to be troublesome. Past experience had made NOL cautious regarding the stress-corrosion and electrolytic coupling of various metals in seawater, and it was necessary to confirm that no problems had been invited by the particular selection represented by this design. One test site, off Newfoundland, was chosen because of its cold temperature and the other, near Puerto Rico, was selected as a contrasting warm area where marine fouling would be most active.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

R.A. Beuttenmuller, NOL

J. Rosenberg, NOL

I.C. Henschen, NOL

## RXD Event Description

1. Title: Feasibility Established for Nuclear-Power Control Unit for Variable-Delay Parachute-Pack Opener (#105)

2. System: Mines Mk 56 and Mk 57

3. Subsystem: Flight Gear (Mine Mk 56)

4. Element: Parachute Pack Mk 28

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event involved the conception of a variable-time control unit for use with the parachute pack for the mine Mark 56. With this control unit, deployment of the parachute can be delayed for any preset period of time from 0 to 4.5 seconds after the mine is released from the aircraft. The power source for this control unit is a radioactive battery whose active material is strontium 90.

   b. Relationship to Contemporary Science and Technology:

At the time of this event, there was a possibility that the parachute canopy might burst if inflated immediately after launch from a high-speed plane. This event was intended to lift such restrictions against high-speed mine-laying at low altitudes; by this event, higher launching speeds were made possible.

   c. Relationship to Succeeding Development or to System Performance:

Almost concurrently with the development of this variable-time control unit, significant advances were made to strengthen the parachute so that it could tolerate high-speed launching. The success of these parachute improvements made it unnecessary to place this device in production.

6. Type of RXD Event: Exploratory Development

Prepared By: R. E. Froehlich Date: 7 Mar 66

7. Key Personnel:

G. L. Fogal, Chief, Flight Gear Section, NOL. Conceived the event and supervised the design of the device.

A. C. Peterson, Flight Gear Section, NOL. Assisted in the design of the device.

L. M. Merrill, Flight Gear Section, NOL. Assisted in the design of the device.

A. M. Moos, Patterson, Moos and Company. Engineered the development of a new radioactive battery important to this event.

W. Tuerck, Patterson, Moos and Company. Assisted Moos in battery development work.

J. E. Langan, Patterson, Moos and Company. Assisted Moos in battery development work.

8. Date of Event:

a. Termination: 1954

b. Initiation: 1952

9. Duration: Eighteen months

10. Organization:

a. (1) Naval Ordnance Laboratory, White Oak

(2) Underwater Ordnance Department

(3) Weapon Mechanisms Division

(4) Flight Gear Section

b. Patterson, Moos and Company

11. Organization Type:

a. Government Laboratory

b. Profit Laboratory, Industrial

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) in-house funds and under Contract No. N60921S-2484

b. Duration- Eighteen months

c. Amount- Estimated $50,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was not placed in production because NOL was able to satisfy the requirements for high-speed launch by strengthening the parachute itself.

b. Previous Activity:

This event was motivated by the need for a control unit with a variable-time delay to enable the mine Mark 56 to meet high-speed launch requirements. NOL sought to prevent parachute bursting at high speed by pursuing two possible solutions: delaying the opening of the parachute for a few seconds so that the mine would lose some of its initial velocity, reducing the open shock on the parachute; and strengthening the cloth for the parachute canopy and the cord for the shroud lines so that the parachute could withstand the severe shock of high-speed deployment. Both solutions were successful, but the second was inherently more reliable and, therefore, this event was not needed.

This event came about in the following manner: G. L. Fogal, co-inventor with G. B. Brown of the delayed-opening parachute pack and his successor as Chief of NOL's Flight Gear Section, was concerned that the direct opening of parachutes at high speeds would cause failure of the flight gear. He was aware that a radioactive battery had been proposed to NOL

13. System Interface Activity:- Continued

by A. M. Moos of Patterson, Moos and Company as an energy source for an underwater demolition device. Fogal believed that a variable timer for delaying the deployment of a parachute could be designed using the new battery as a long-life energy source capable of operating at low temperatures. He understood the design of such a device and was successful.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

G. L. Fogal, General Electric Company

A. C. Peterson, NOL

Documents:

NOL files relating to Timing Device No. 5001 produced by Patterson, Moos and Company under contract N60921S-2484.

RXD Event Description

1. Title: Invention of Swaging Device To Arrest Payment of Mooring Rope (#70)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mooring (Mine Mk 57)

4. Element: Anchor Mk 57

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the invention of a cable-gripping device for arresting the payout of mooring cable from the anchor of the mine Mark 57. It is an explosively driven swaging device that acts when payment of a predetermined amount of mooring cable has been sensed by the anchor's mooring system. In this mooring system, magnetic poles are imposed upon the steel mooring cable at 1-foot increments; the sensing of these poles measures the cable as it leaves a dispenser. The dispenser feature is significant; it is an arrangement wherein the cable is stowed,not on a rotatable reel in the conventional manner,but in a stationary drum from which it is paid out, much in the manner of a ball of string, from the center. Whereas cable payment from a reel can be stopped by blocking the reel's rotation, the use of a dispenser requires that the cable itself be grabbed and held.

b. Relationship to Contemporary Science and Technology:

At the time of this event, a cable imprinted with magnetic poles could, of course, be stowed on a reel and its payment stopped in the usual manner. Two problems were inherent in reel systems, however, First, a reel loaded with hundreds of feet of mooring rope is very heavy and considerable energy is required to initiate its rotation. Second, because the reel, once started, cannot be allowed to race or overrun, a brake is necessary. But a brake adds a further restriction to starting the rotation of the reel, already burdened by inertia. When a dispenser system was selected as the preferred method for the stowage and payment of the mooring cable, this event provided a means of arresting the payment of the mooring cable while it was running at a rate of about 15 feet per second. The device which performs this function is described in the disclosure for Patent No. 3,016,828.

Prepared By: Leon J. Lofthus, NOL (WO) Date: 3 Mar 66

5. Technical Significance:- Continued

c. Relationship to Succeeding Development or to System Performance:

Use of this swaging device improved the general system performance by making it possible to fully capitalize on the new concept introduced for the automatic mooring of naval mines.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

C. F. Bowersett, Chief, Cases and Anchors Branch, NOL. Conceived the explosively driven swager and was granted a patent for its invention.

H. C. Thoben, Chief of a design group within the Cases and Anchors Branch, NOL. Assisted Bowersett in the development and engineering of this device.

W. B. Johnson, Mechanical Engineer, Cases and Anchors Branch, NOL. Worked under Thoben in the development of this device.

F. Peregrim, Mechanical Engineer, Cases and Anchors Branch, NOL. Worked under Thoben in the development of the device.

8. Date of Event:

a. Termination: 1951

b. Initiation: 1951

9. Duration: Five months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

d. Cases and Anchors Branch

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds

b. Duration- Five months

c. Amount- Estimated $8,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used as an essential part of the mooring system for the mine Mark 57. The device is not limited to this mine application but is capable of use in any situation demanding the abrupt stopping of a running cable wherein the reel cannot be blocked.

b. Previous Activity:

When a need for this type of device was recognized, Bowersett surveyed the swager fittings industry to see if "one-shot" swagers were available. He presumed that such a device could be adapted for use with the new reelless mooring system of the mine Mark 57 and that it could be driven by explosive energy. He found that the industry had no experience with one-shot swagers; rather, the standard arrangement was to cold-flow the fitting by means of a succession of blows produced by a rotating hammer. An attempt had been made by the Mine Safety Appliance Company to develop a device of the type sought by Bowersett, but their effort was disappointing because it involved cutting and otherwise injuring the wires comprising the cable. With the assistance of Johnson, Thoben, and Peregrim, Bowersett initiated the design of his device at NOL. He succeeded in solving the problem of cable damage and was able to stop the cable with a single explosive force.

14. RXD Event Circumstances:

NOL was aware of the advantages offered by swaged fittings as cable terminations. It was believed that these fittings, normally swaged onto a cable by a series of blows which causes the metal of the fitting to flow into the cable

14. RXD Event Circumstances:- Continued

interstices, might be locked to the cable by a single, massive blow. Further, if the fitting were part of the anchor proper, the cable would in fact be locked to the anchor. Obviously, the blow would have to be an overwhelming one, quickly accomplished so that it would grip the running cable. NOL believed that this could be accomplished by explosive means.

15. Sources:

Persons Interviewed:

C. F. Bowersett, NOL

W. B. Johnson, NOL

F. K. Peregrim, NOL

Documents:

Files in Mine and Depth Charge

# RXD Event Description

1. Title: Invention of Magnetic Metering Method for Mooring Mine Case at Preselected Depths (#65)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mooring (Mine Mk 57)

4. Element: Anchor Mk 57

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event concerns an entirely new concept for the automatic mooring of underwater mines. The desired depth of the moored case is preset into the mooring system housed within the anchor. When planted, the case and anchor sink to the bottom, locked together for the duration of the delay-rising period. While on the bottom, a sensing device notes the pressure—and thus the depth—of the water. It automatically subtracts the preset depth from this total depth to arrive at the length of cable that must be payed from the anchor to allow the buoyant case to ascend to its permanent moored position. At the end of the delay-rising period, the case is unlocked and starts toward the surface. Magnetic poles, imprinted every foot along the length of the steel mooring cable, are used to measure the amount of cable pulled from the anchor. A detector is used to sense and count the poles as they pass. When a number equivalent to the predetermined length of cable is counted, further payment is halted by an explosively driven swaging device which grabs and stops the cable.

This new concept is closely associated with several other events. It uses the polarized magnetic field detector and the reelless mooring-cable dispenser, it has occasioned the development of a special technique for superimposing magnetic poles upon the mooring cable, and it involves the very accurate depth-sensing system.

   b. Relationship to Contemporary Science and Technology:

This event is an advance over contemporary mooring systems as represented

Prepared By: L. J. Lofthus, NOL (WO) Date: 3 May 66

5. Technical Significance:- Continued

by the plummet system of the mines Mark 6, Mark 16, and Mark 23, and the "loose-bight" system of the mines Mark 10 and Mark 56. These are largely mechanical in nature and their working parts are unavoidably exposed to corrosion, mud and marine fouling, and other environmental hazards which can prevent their successful operation, particularly after a prolonged delay-rising period. In contrast, the system reported here is completely enclosed. The plummet and loose-bight systems have an inherent error. Each attempts to establish depth by traversing the depth by a negatively buoyant plummet or a positively buoyant case. In any situation other than ideal (zero current, zero skid), the cable payed out will lie in a catenary and its length will in fact be greater than the depth. Thus, these systems tend to moor their cases more shallow than intended. Again in contrast, the system introduced by this event measures true depth by a pressure-sensing device and then pays out a length of cable determined in an absolute manner by the magnetic metering arrangement. This invention is recognized by Patent Number 3,039,391.

c. Relationship to Succeeding Development or to System Performance:

The magnetic metering system has proved successful in its ability to accurately moor the case of the mine Mark 57 over the extreme range cited by the operational requirements for this mine.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

L. Michelson, Chief, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. Directed the work and application of the event.

L. J. Lofthus, Mechanical Engineer, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. Conceived this event.

J. C. Goff, Mechanical Engineer, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. Constructed the breadboard model under the supervision of Lofthus.

H. Price, Mechanical Engineer, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. Subsequently engineered this event and applied it to the system.

7. Key Personnel:- Continued

W. O. Allen, Mechanical Engineer, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. Assisted Price.

K. Studenick, Mechanical Engineer, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. Assisted Price.

8. Date of Event:

a. Termination: 1950

b. Initiation: 1950

9. Duration: Two months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy(Bureau of Ordnance) funds

b. Duration- Two months

c. Amount- Estimated $1,000

d. Costs for the engineering and evaluation of this concept as applied to the mine Mark 57 exceeded $100,000.

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

The use of this event in the surface-laid mine was not pursued into

13. System Interface Activity:- Continued

production. Shortly after Lofthus proposed the new system, the Hartford Empire project was cancelled because of lack of progress. This event was applied to the mine Mark 57, however, which was under design by NOL at the same time.

b. Previous Activity:

L. J. Lofthus, of NOL's Mine and Depth Charge Division, conceived this event. He was motivated to do so for reasons entirely apart from the mine Mark 57, which capitalized on the idea. He was concerned that the mooring system under development by the Hartford Empire Company for the surface-laid successor to the mines Mark 6 and Mark 16 was unsound and unlikely to work. This contractor was responsible for the development of the entire mine, and proposed a mechanical mooring system that Lofthus believed was laden with problems that would prevent it from acting accurately, if at all. He conceived the magnetic metering system as a replacement. Michelson endorsed the idea and directed that it should be applied to the Hartford Empire program and, significantly, that it should be packaged in a manner that would facilitate its use in other moored mines.

14. RXD Event Circumstances:

NOL was not responsible for the design of the surface-laid mine under development by the Hartford Empire Company, but it did monitor the program and was of the opinion that the system proposed for mooring this mine was unrealistic and unworkable. Early tests conducted by Hartford Empire Company in NOL's mine tank facility confirmed this apprehension. The contractor's general inability to recognize the problems encountered by devices that must work in the severe environment of the sea eventually caused the cancellation of this project by the Bureau of Ordnance. However, NOL believed that this system would also serve the purpose of the mine Mark 57 and it pursued this application and placed it in production.

15. Sources:

Person Interviewed:

L. J. Lofthus, NOL

15. Sources:- Continued

Documents:

Memorandum: L. J. Lofthus to UM Division (NOL), 18 April 1950.

Memorandum: L. Michelsen to L. J. Lofthus, 1 May 1950.

Disclosure for U.S. Patent Number 3,039,391

## RXD Event Description

1. Title: Feasibility Established for Polarized Magnetic-Field Detector for Responding to Alternate Magnetic Fields Imprinted on Mooring Cable (#66)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mooring (Mine Mk 57)

4. Element: Magnetic Pole Detector Mk 10

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event established the practicality of detecting in a wire rope a magnetic signature having a wave pattern of alternate peaks of opposite polarity. The detector is essentially a coil system through which the cable must pass as it leaves the anchor. When a magnetized portion travels through the coil, an electromotive force is generated which activates a relay system to record the passage as a count. One count is equivalent to the passing of one foot of cable.

   b. Relationship to Contemporary Science and Technology:

The mooring system for the mine Mark 57 uses magnetic poles of alternate polarity placed 12 inches apart along the entire length of the steel mooring cable. A detector is required to sense and count these poles as the cable is payed from the anchor. When a desired length--automatically calculated by the system to moor the case at a preselected depth--has been payed out, the system acts to block further payment. The detector was designed to be independent of cable speed and to be invulnerable to temperatures and shocks to which the mine might be subjected. It is described in the disclosure for U.S. Patent No. 3,039,391.

   c. Relationship to Succeeding Development or to System Performance:

This event is essential to the magnetically metered mooring system for the mine Mark 57. Together with related event, it insured the success of the overall system.

Prepared By: J. A. Dohner, NOL (WO) Date: 1 Mar 66

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

L. J. Lofthus, Mechanical Engineer, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. Conceived the novel mooring system of which this event is a part.

J. C. Goff, Mechanical Engineer, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. As Lofthus' assistant, built the breadboard model which demonstrated the system's feasibility.

H. Price, Mechanical Engineer, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. Engineered the detector for production.

8. Date of Event:

a. Termination: 1950

b. Initiation: 1950

9. Duration: Four months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds

b. Duration- Four months

c. Amount- Estimated $2,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This detector was perfected and placed in production as part of the magnetically metered mooring system for the mine Mark 57.

b. Previous Activity:

The potential advantages offered by the magnetically metered mooring system in terms of mooring accuracy, immunity to seawater exposure and marine fouling, and its capability to operate over extreme ranges of depth motivated NOL to pursue its development.

14. RXD Event Circumstances:

The magnetically metered mooring system was first conceived as a possible substitute for a mechanical mooring system being developed by a contractor to the Bureau of Ordnance for a general-purpose surface-laid mine. NOL monitored this work and was not impressed by the contractor's concept. When the whole project collapsed because of the growing disappointment by the Navy in the overall concept, the system was used by NOL for its own mine Mark 57 program that was just getting underway at the time.

15. Information Sources:

Person Interviewed:

L. J. Lofthus, NOL

Documents:

Disclosure for U.S. Patent No. 3,039,391

NOL TN 4312, "Detector, Magnetic Pole, Mk 10 Mod 0; description of," dated 19 August 1953.

## RXD Event Description

1. Title: Feasibility Established for Stowing and Paying Mooring Cable with Superimposed Magnetic Poles from Stationary Dispenser (#67)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mooring (Mine Mk 57)

4. Element: Cable Dispenser Mk 1

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event consisted of the demonstration that a steel cable imprinted with magnetic poles of opposite polarity every foot along its length could be stored without degrading in a reelless stationary dispenser and later be payed from that dispenser without difficulty. The mooring cable concerned is used with the magnetically metered mooring system introduced by the mine Mark 57.

b. Relationship to Contemporary Science and Technology:

Quite obviously the several hundred feet of cable required for this mine could be stowed on a conventional reel, but NOL wished to avoid the problem of starting the rotation of such a reel with the rather modest forces provided by the buoyant mine case. It was NOL's belief that a reel would tend to be immobilized by mud that could accumulate within the anchor during the delay-rising period, and that substantial force might be required to break it loose. NOL also wished to avoid the dangers of cable "overrunning" that can occur if this rotation, once started, is not uniform. Apart from these problems of cable payment, NOL was also concerned that the intensity of the magnetic section was adjacent and in contact with a nonmagnetic section. Prototype dispensers were fabricated and loaded with magnetized lengths of cable. These units were shock tested, vibrated, stowed for long periods of time and generally abused. There was no evidence of pole degradation or second generation poles.

Prepared By: Leon J. Lofthus, NOL (WO) Date: 4 Mar 66

5. Technical Significance:- Continued

c. Relationship to Succeeding Development or to System Performance:

This event, together with related events, insured the suitability of the novel mooring system introduced by the mine Mark 57.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

R. Weller, Chief, Engineering Department, NOL. Introduced the original concept of the stationary dispenser.

C. C. Vogt, Electrical Engineer, Mine and Depth Charge Division, Engineering Department, NOL. Further developed the dispenser idea.

W. O. Allen, Mechanical Engineer, Mine and Depth Charge Division, Engineering Department, NOL. Assisted Vogt in this event.

H. Price, Mechanical Engineer, Mine and Depth Charge Division, Engineering Department, NOL. Assisted Vogt in this event.

8. Date of Event:

a. Termination: 1953

b. Initiation: 1953

9. Duration: Six months

10. Organization:

a. Naval Ordnance Laboratory, White

b. Engineering Department

c. Mine and Depth Charge Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds

b. Duration- Six months

c. Amount- Estimated $3,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was refined and placed in production as part of the mooring system of the mine Mark 57.

b. Previous Activity:

The establishment of the feasibility of stowing magnetized cable and paying that cable from a reelless dispenser was essential to the successful functioning of the novel mooring system introduced by the mine Mark 57.

14. RXD Event Circumstances:

The magnetically metered mooring system was first conceived as a possible substitute for a mechanical mooring system being developed by a contractor for a general-purpose surface-laid mine. NOL was aware of this work and was not impressed by the contractor's concept. Because of this and other problems throughout the design, the whole project collapsed before NOL could aid it by this idea. The system was then used by NOL for its own mine Mark 57 program which was just getting under way at the time. All shock, vibration, and accelerated aging tests were conveniently conducted by NOL in its enviromental simulation facility.

15. Sources:

Persons Interviewed:

H. W. Price, University of Maryland

W. O. Allen, NOL

S. E. West, NOL

## RXD Event Description

1. Title: Development of Technique for Superimposing Magnetic Poles of Uniform Strength on Wire Ropes (#68)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mooring (Mine Mk 57)

4. Element: Cable Dispenser Mk 1

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event involved the development of a technique for reliably superimposing magnetic poles of opposite polarity and uniform strength at regular increments along the length of steel wire rope.

   b. Relationship to Contemporary Science and Technology

The magnetically metered mooring system introduced by the mine Mark 57 uses magnetic poles imprinted at regular intervals along the length of the mooring cable as a means for measuring and controlling the payment of this cable from the mine anchor. Each pole is significant; if a pole is too weak to trigger the detector or counter, the incremental length will not be recorded and the overall length will be in error. This technique imposes uniformly strong magnetic poles alternating in polarity every 12 inches along the full length of the cable.

   c. Relationship to Succeeding Development or to System Performance:

By means of this event, a technique was developed for use in production to imprint such poles on running cable. This event, together with related events, acted to insure the suitability of the new mooring system.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

H. W. Price, Mechanical Engineer, Mine and Depth Charge Division,

Prepared By: J. A. Dohner, NOL (WO) Date: 3 Mar 66

7. Key Personnel:- Continued

NOL. Developed this technique.

8. Date of Event:

a. Termination: 1951

b. Initiation: 1951

9. Duration: Three months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds

b. Duration- Three months

c. Amount- Estimated $3,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

Techniques developed by NOL were successful and were readily adapted for use in rapid and economical production of the mooring cable for the Mine Mk 57.

b. Previous Activity:

It was imperative that the magnetic poles used to trigger the detector,

13. System Interface Activity:- Continued

and thereby register the payment of an incremental length of cable, be strong and well localized. By using NOL's shop facilities, Price was able to fabricate a breadboard arrangement for imposing magnetic poles on steel cable. He was able to establish the permanency of these poles by exposing the cable to accelerated aging tests in NOL's environmental simulation facilities. He was then able to confirm the effectiveness and strength of the poles by using the cable in experimental prototypes of the mine Mark 57 mooring system.

14. RXD Event Circumstances: None

15. Information Sources:

Person Interviewed:

L. J. Lofthus, NOL.

Documents:

Notes by H. W. Price, dated 28 June 1951

RXD Event Description

1. Title: Invention of Anchor Device Capable of Accurate Determination of Water Depth Over Extreme Range and Under Severe Environments (#69)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mooring (Mine Mk 57)

4. Element: Depth Control Unit Mk 78

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the invention of a device capable of determining water depth with high accuracy after being subjected to long-term storage and the shocks of submarine ejection and bottom impact. It determines water depth by measuring the weight of water above the device and converting this measurement into a linear output. This output is unaffected by temperature variations and forces exerted by the earth's gravitational field, or by shocks encountered during torpedo tube launching and striking the sea bottom. The helical bourdon tube is the key sensing element in this automatic mooring system.

b. Relationship to Contemporary Science and Technology:

This event advanced the state of the art by providing the first application in a tactical device of a helical bourdon tube to determine the total depth of water with almost laboratory accuracy. The invention is described in the disclosure for U. S. Patent No. 2,824,516.

c. This event, together with related event, contributed to the successful functioning of the automatic mooring system for underwater mines.

6. Type of RXD Event: Exploratory Development

Prepared By: Walter O. Allen, NOL (WO) Date: 22 Feb 66

7. Key Personnel:

D. K. Studenick, Mechanical Engineer, Mine and Depth Charge Division, NOL. The inventor of this device.

W. O. Allen, Mine and Depth Charge Division, NOL. Supervised the work of Studenick and reduced the invention to practice after Studenick transferred to another work area within NOL.

8. Date of Event:

a. Termination: 1952

b. Initiation: 1952

9. Duration: One month

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds

b. Duration- One month

c. Amount- Estimated $80,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in the depth-control unit Mark 78 which functions

13. System Interface Activity:- Continued

after the delay-rising period to moor the case at any desired preset depth. It is an essential part of the magnetically metered mooring system introduced by the Mark 57. It is used to accurately establish the total depth of water into which the mine has been planted. From this depth, the present depth at which the mine must eventually be moored is automatically subtracted to establish the length of mooring cable that must be payed from the anchor.

b. Previous Activity:

In September 1951, Contract NOrd 12119 was awarded by NOL to Industrial Research Products, Inc., for the design and development of a depth-measuring device to be used with the mine Mark 57 mooring system. IRP's device failed to meet the design requirements, and a new concept invented by Studenick was pursued. Although there was some skepticism that he would be able to achieve the necessary accuracy with a device that would be exposed to rather severe shock and vibration, Studenick persisted and was able to produce a design that fully satisfied the demanding requirements of the mine Mark 57 mooring system.

14. RXD Event Circumstances: N/A

15. Sources:

Persons Interviewed:

D. K. Studenick, NOL

W. O. Allen, NOL

Documents:

NOL Notebook Serial No. 80-3511

# RXD Event Description

1. Title: Feasibility Established for High-Accuracy Depth Recorder for Testing Mooring System (#76)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mooring (Mine Mk 57)

4. Element: Test and Evaluation (equipment)

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the conception and demonstration of a depth-sensing and recording instrument capable of high accuracy over an extreme range of depths.

b. Relationship to Contemporary Science and Technology:

The magnetically metered mooring system introduced by the mine Mark 57 uses a depth sensor to establish the total depth of water in which the mine has been planted. The system automatically subtracts from this depth the preset depth at which the case is to be moored. The remainder is equal to the length of cable that must be paid out from the anchor to permit the case to take its permanent moored position. The depth sensor used for this purpose is necessarily a very accurate device. To check its performance, an instrument capable of even greater accuracy is required, and it must be able to function under field conditions. Contemporary sonic depth recorders had difficulty in establishing the exact bottom and, moreover, were affected by temperature differences throughout the depth. Sounding lines were inexact because of drift and displacement from the point of measurement. This event provided a device capable of extreme accuracy, even under severe environments.

c. Relationship to Succeeding Development or to System Performance:

Although this device was not a part of the tactical mooring system for the mine Mark 57, it was essential to the development and evaluation of this system.

Prepared By: D. B. Frazier, NOL (WO) Date: 1 Mar 66

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

D. K. Studenick, Mechanical Engineer, Mine and Depth Charge Division, NOL. Inventor of this device. He became aware of a need for a device of this type coincidentally with his work on the mooring system for the mine Mark 57.

W. O. Allen, Mine and Depth Charge Division, NOL. Supervised Strudenick's work and completed the instrument's development after Studenick transferred to another NOL program.

8. Date of Event:

a. Termination: 1955

b. Initiation: 1955

9. Duration: Six months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds

b. Duration: Six months

c. Amount; Estimated $5,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This device was used during the development in evaluation of the

13. System Interface Activity:- Continued

depth control unit Mark 78 for use in the new mooring system incorporated in the mine Mark 57.

b. Previous Activity:

This event was motivated by the need to confirm the accuracy for the depth-sensing portion of the tactical mooring system. Studenick was the inventor of the extremely accurate depth control unit Mark 78. In the development of this device, he found it impossible to establish the limits of its accuracy by using contemporary instruments and methods. For this reason he was forced to conceive and develop an entirely new instrument of even greater accuracy so that he would have a means of evaluating the performance of the tactical device. Two independent pressure-sensing elements were used, each accurate within 1/2 percent to produce linear depth records, which were then averaged. The performance of the new instrument was confirmed by means of tests conducted in the very deep and very quiet water available at the Navy Electronics Laboratory's facility located in Lake Pend Oreille, Idaho.

14. RXD Event Circumstances: None

15. Information Sources:

Persons Interviewed:

D. K. Studenick, NOL

W. O. Allen, NOL

Document:

NOL Notebook Serial No. 80-3511

## RXD Event Description

1. Title: Invention of Multianode Electrolytic Timing Devices Capable of Multiplicity of Time Controls (#79)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Delayed Rising

4. Element: Clock Delay Mk 21

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the invention of a means for achieving multiple time delays within a single electrolytic cell. This is accomplished by introducing a new type of anode construction for use with a standard electrodeposition timing system.

b. Relationship to Contemporary Science and Technology:

Conventional electrochemical timers use a wire passing through the cell to comprise the anode; the metal housing of the cell constitutes the cathode. When direct current is applied to the cell, electrodeposition occurs at the cathode at the expense of the anode until the anode is weakended to the extent that it is broken by an externally applied spring-load. This anode system, although quite small, imposes some limitation on the configuration of the cell; moreover, the accommodation of more than one wire in a cell to obtain a selection of time delays would be most difficult. By this event the anode was changed, in effect, to a half-length wire which enters the cell but which does not pass through. The end of the wire within the cell is enlarged in the manner of a head on a pin. When deplating reduces the head to the size of the shank, it can no longer restrain the load of an external spring; the latter then acts to operate electrical switches in the mine delay-rising circuits. Because this type of anode is less bulky and restrictive than its predecessor, a number can be accommodated within a cell, thus making possible a multiplicity of delays within a single cell. This invention is recognized by Notice of Allowability, Serial No. 34,598.

Prepared By: Leon J. Lofthus, NOL (WO) Date: 6 May 66

5. Technical Significance:- Continued

c. Relationship to Succeeding Development or to System Performance:

This event improved the overall reliability of the mines Mark 56 and Mark 57. It also helped to reduce their cost and complexity.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

B. W. Svrjcek, Mechanical Engineer, Weapons Systems Materials Division, Underwater Mechanical Engineering Department, NOL. Specialist in electrochemical timing devices. Conceived and demonstrated this event.

L. E. Kissinger, Chemical Engineer, Weapons Systems Materials Division, Underwater Mechanical Engineering Department, NOL. Also a specialist in electrochemical timing devices, he assisted Svrjcek in this invention.

8. Date of Event:

a. Termination: 1957

b. Initiation: 1957

9. Duration: Five months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Mechanical Engineering Department

c. Weapons Systems Materials Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds

b. Duration- Five months

c. Amount- Estimated $25,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event made possible the design of the clock delay Mark 21, the timer device which controls the delayed rising of both mines Mk 56 and Mk 57 by closing a sequence of switches in their mooring-system circuits. It is a direct replacement for the electromechanical clock delay Mark 18. The basic concept of this new anode also made possible the design of very small electrolytic cells which have been used as time controls in other ordnance systems, sonobuoys, weather balloons, and in NASA satellites.

b. Previous Activity:

This event was motivated by the operational requirement of the mines Mk 56 and Mk 57 for a delayed-rising capability. The control of this capability for these mines, as provided by the electromechanical clock delay Mark 18, was relatively unreliable after being subjected to the shock of water impact at 200 feet per second. The still high (99.9%) reliability of electrolytic timing devices after the same shock made them highly suitable for this purpose; therefore, NOL wanted to replace the clock delay Mark 18 with the very rugged and less complex electrolytic type of timing device. Another motivating factor was the relatively low (approximately $66) cost of the electrolytic device, compared with the cost of the electromechanical type (approximately $117). The envelope for the clock delay Mark 18 was established by a modular concept, however, and it was essential that any replacement of this device have an identical shape and size. An electrolytic timer using conventional cells and capable of operating a sequence of switches would have been too bulky to contain within the clock delay Mark 18 envelope. Svrjcek and Kissinger therefore worked on the problem of adapting the standard cell design to accommodate more than one timing function and to compact it into the established envelope.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

B. W. Svrjcek, NOL

L. E. Kissinger, NOL

15. Sources:- Continued

Document:

NOL Patent File, Case D-2499 (Navy Case No. 27,703).

RXD Event Description

1. Title: Research in Bubble Pulse Phenomenon and Its Effect on Ships and Submarines (#86)

2. Weapon System: Mines Mk 56 and 57

3. Subsystem: Explosive

4. Element: Main Charge

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns research on the bubble pulse phenomenon associated with underwater explosions and the manner in which it causes damage to ships and submarines.

b. Relationship to Contemporary Science and Technology:

At the time of this event, theories and experimental data on the subject of damage by underwater explosion were inadequate. This event advanced the state of the art by providing a great deal of data, much of it derived from full-scale tests. As a result of this research regarding the bubble pulse phenomenon, damage contours were drawn which were found to differ considerably from those generally expected up to the time of this event. The new damage curves were much more realistic. This event was partly reported in NAVORD Report 2786.

c. Relationship to Succeeding Development or to System Performance:

By means of this event, weapons-systems designers were and are able to better plan a selection of sensitivities for their firing systems to provide maximum damage against a variety of targets.

6. Type of RXD Event: Research

7. Key Personnel:

H. D. Snay, Senior Research Associate, Explosives Research Department,

Prepared By: Elijah Swift, Jr., NOL (WO) Date: 14 Mar 66

7. Key Personnel:- Continued

NOL. Performed significant research. His definitive paper on damage analysis is considered a milestone by the explosives community.

C. B. Izard, Explosives Research Department, NOL. Assisted Snay and conducted experiments using scale explosive charges in a vacuum tank.

J. E. Goertner, Explosives Research Department, NOL. Worked with Izard on the experiments.

J. J. Fischer, Explosives Research Department, NOL. Performed computations and prepared necessary graphics.

E. Swift, Jr., Chief, Explosions Hydrodynamics Division, Explosives Research Department, NOL. Provided program guidance.

A. B. Focke, Naval Electronics Laboratory, NOL. Provided war-damage data.

8. Date of Event:

a. Termination: 1954

b. Initiation: 1950

9. Duration: Approximately four years

10. Organization:

a. 1. Naval Ordnance Laboratory, White Oak

2. Explosives Research Department

3. Explosions Hydrodynamics Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds and foreign funds

12. Financial Support:- Continued

b. Duration- Approximately four years; funds were available as required.

c. Amount- Estimated $350,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in the mines Mark 56 and 57. Work in this area continues today.

b. Previous Activity:

This event was motivated by the need for more data on damage by underwater explosions. Immediately after World War II, some evidence had become available through the British Ship Target Trials, but this work was largely confined to explosions fired to the side of submarines. Little was known regarding the effect of the sea bed, the problems of shallow explosions, underkeel explosions against surfaced submarines, etc. The Bureau of Naval Ordnance conducted studies to provide data useful to designers of new underwater weapons, especially those intended for use against submarines. Three important types of damage were examined: local, occurring in the region immediately abreast of the explosion; shock, which propagates through the water as a spherical pressure wave and usually affects equipment and machinery; and whipping, caused by the flexural vibration of the vessel as a whole. Whipping is probably the most dangerous type of damage any vessel can experience. Whereas the first two types can slow and even immobilize a vessel, whipping can cause it to sink. A detailed study was conducted regarding the effects of both shock wave and bubble pulse phenomena in producing the various types of damage. It was established that the bubble pulse is very significant. The gas bubble formed underwater by the reaction products of an explosion isolates and releases pressure pulse at each bubble minimum. These pulses follow the shock wave which is emitted very shortly after detonation of the charge. A vessel exposed to these pulses is subjected to repeated cycles of pressure, markedly above and then below the ambient condition. This pulsing action induces flexing of the vessel's structure and can result in ruptures. A damage mechanism such as this, which threatens the watertight integrity of a ship or submarine, is highly significant to the design of weapons such as the mines Mark 56 and Mark 57.

14. RXD Event Circumstances:

The first evidence of the significance of the bubble pulse was found in the early 1920's when a German World War I submarine was subjected to an explosive test. In this instance the explosion was so shallow as to be vented to the surface; the bubble pulsation was disturbed and no bubble pulse was emitted. The explosion caused little damage and, although it was not appreciated at the time, it is now believed that the failure to do more damage was caused by the absence of the bubble pulse. The effect was again demonstrated in 1948 by tests against a World War II German submarine. More recently, very convincing evidence of the importance of the bubble pulse was produced by the Underwater Explosion Research Division at the Norfolk Naval Shipyard, using submarine models.

15. Sources:

Document:

NAVORD Report 2786, Optimum Mine Characteristics, Part 2, "Damage Analysis," H. D. Snay, 31 March 1953.

## RXD Event Description

1. Title: Development of Fabrication and Processing Techniques for Nonmagnetic, Electrically Resistant Metal Mine Case (#91)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mine Case (Mine Mk 56)

4. Element:

   a. Mechanism Compartment Mk 1

   b. Explosive Section Mk 1

   c. Instrument Rack Mk 2

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event concerns the development of original fabrication and processing techniques to permit the use of special steel alloys as mine-case material.

   b. Relationship to Contemporary Science and Technology:

Manganese-nickel steel was the first material selected for the case and instrument rack of the mine Mark 56. Later this material was superseded by a new and stronger chrome-manganese alloy. In both instances, NOL was confronted with the problem of using these special alloys for purposes other than those for which they were developed. The former was intended as a transformer-case material; and the latter as a heat-resistant material for jet-engine usage. Their use as mine-case material was conditioned by the fact that the end product had to be as electrically resistive and nonmagnetic as possible. Many fabrication processes essential to their use for mine cases tended to degrade the initially nonmagnetic quality of these steel alloys. The processes included welding, spinning, pressing, roll forming and heat treating. The shaping

Prepared By: Irving C. Henschen, NOL (WO) Date: 2 Mar 66

5. Technical Significance:- Continued

processes tend to "perm up" the material, and the heat treatments resulted in a scale which was highly magnetic. Because industry was unable to recomment processes and treatments that would minimize these effects, NOL found it necessary to study and develop original ones for this purpose. The outcomes of these studies were the following documents: NOL TN4637, "Techniques for Successful Fabrication of Manganese-Nickel Nonmagnetic Steel"; and OD15330. "Fabrication Procedures for Manganese-Nickel Steel Weldments." When actual experience with these metals revealed a proneness to degradation by stress corrosion, NOL evolved special annealing and pickling treatments that reduced this tendency.

c. Relationship to Succeeding Development or to System Performance:

This event made possible the economical production of high-performance mine cases.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

M. W. Crawford, Mechanical Engineer, Mine and Depth Charge Division Underwater Ordnance Department, NOL. Responsible for studies concerning both types of steel alloy.

I. C. Henschen, Mechanical Engineer, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. Also responsible for studies concerning both types of steel alloy.

W. O. Allen, Mechanical Engineer, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. Responsible for studies concerning the use of manganese-nickel steel as mine case material.

H. Long, Allegheny Ludlum Steel Corporation. Assisted the NOL team in the studies, representing the producer of the alloys.

F. Freidlein, Charles T. Brandt Company, Incorporated. Assisted the NOL team in the studies, representing the fabrication.

8. Date of Event:

a. Termination: 1962

b. Initiation: 1955

c. The techniques for the manganese-nickel steel were established in 1955; comparable techniques were established for chrome-manganese steel in 1962.

9. Duration: Approximately twelve months total.

10. Organization:

a. 1. Naval Ordnance Laboratory, White Oak

2. Underwater Ordnance Department

3. Mine and Depth Charge Division

b. 1. Allegheny Ludlum Steel Corporation

2. Research Laboratory

c. Charles T. Brandt Company, Incorporated

11. Organization Type:

a. Government Laboratory

b. Profit Laboratory, Industrial

c. Profit Laboratory, Industrial

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds

b. Duration- Approximately twelve months; funds were available as required.

c. Amount- Estimated $125,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

As a result of this event, processes and techniques were established for use in the production of the mechanism compartment and explosive sections which comprise the case for the mine Mark 56, plus the instrument rack for this mine and the mine Mark 57.

b. Previous Activity:

One of the firing systems used with the mine Mark 56 required that all material used in the vicinity of this system be nonmagnetic and electrically resistive. The materials selected for this purpose were the products of industry. The special techniques that were necessary to make these materials suitable for this unique application were evolved by NOL with the assistance of the producer of these alloys, the Allegheny Ludlum Steel Corporation, and the fabricator of the prototype lots, the Charles T. Brandt Company, Inc.

14. RXD Event Circumstances:

At the outset, NOL was confronted withthe problem of using materials, specially developed for other applications, for an entirely unique purpose. NOL evolved procedures that allowed this use and produced prototype models, first of manganese-nickel steel. When after a period of time it was found that these units were plagued by filamentary cracks suggesting a vulnerability to stress corrosion, it was necessary to refine these procedures and introduce additional techniques to minimize this phenomenon. If this event had not been possible, titanium would have been used as the sole known replacement--with a consequent cost increase of at least $2,000 per case.

15. Sources:

Persons Interviewed:

M. W. Crawford, NOL

I. C. Henschen, NOL

## RXD Event Description

1. Title: Invention of Tensioning and Coating Device for Filament-Wound Structures (#94)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mine Case (Mine Mk 57)

4. Element:

   a. Mechanism Compartment Mk 2

   b. Explosive Section Mk 2

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event concerns the invention of a means for controlling filament tension in the winding of reinforced plastic structures and for controlling the amount of resin applied to this filament during this process.

   b. Relationship to Contemporary Science and Technology:

Reinforced plastic structures can be made by the winding of glass thread coated with a bonding matrix onto a rotating mandrel and subsequently curing these shapes at elevated temperatures. When this technique was first tried, it was apparent that some means for controlling the tension of the thread of filament was necessary and that the ratio of resin to glass would have to be regulated. NOL conducted a series of studies to determine the optimum tension and the preferred resin-glass ratio for use with structures intended for underwater application. It pursued these studies in part by inventing and building a device which could insure the proper tension and the desired coating in production. This invention is recognized by U.S. Patent No. 3,112,897.

   c. Relationship to Succeeding Development or to System Performance:

This and related event contributed to NOL's eventual success in producing

Prepared By: W. T. Johnson, NOL (WO) Date: 4 Mar 66

5. Technical Significance:- Continued

high-quality, uniform structures in reinforced plastics capable of long-term underwater submergence at great depths.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

F. R. Barnet, Chemical Engineer, Non-Metallic Materials Division, Chemistry Research Department, NOL. Directed the work of this event.

P. W. Erickson, Organic Chemist, Non-Metallic Materials Division, Chemistry Research Department, NOL. Participated in the study culminating in this event.

S. Prosen, Mechanical Engineer, Non-Metallic Materials Division, Chemistry Research Department, NOL. Participated in the study.

R. W. Eshbaugh, Mechanical Engineer, Non-Metallic Materials Division, Chemistry Research Department, NOL. Participated in the study and is recognized as the inventor in the patent for this invention.

M. A. Kinna, Chemical Engineer, Non-Metallic Materials Division, Chemistry Research Department, NOL. Participated in the study.

W. T. Johnson, Engineering Technician, Non-Metallic Materials Division, Chemistry Research Department, NOL. Participated in the study.

8. Date of Event:

a. Termination: 1956

b. Initiation: 1956

9. Duration: Six months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

10. Organization:- Continued

b. Chemistry Research Department

c. Non-Metallic Materials Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds

b. Duration- Six months

c. Amount- Estimated $100,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in the manufacture of cases for the mine Mark 57. The techniques that evolved from this event have since been used in the manufacture of rocket motor cases, heat shields for reentry bodies, and in other ordnance and commercial applications.

b. Previous Activity:

This event was motivated by the need for a nonmagnetic, electrically resistive case for the mine Mark 57. NOL believed that an all-plastic structure would be ideally compatible with this firing system. However, the technology of the time was not capable of producing such a structure. This event was part of a series of studies conducted by NOL toward that end.

14. RXD Event Circumstances:

The people responsible for this event were interested in projecting the use of reinforced plastics into all areas that could profit from the special qualities of this material. The mine Mark 57 provided only a portion of this potential use. Variations of this and related events have been used by private industry.

15. Sources:

Persons Interviewed:

S. Prosen, NOL

E. West, NOL

M. A. Kinna, NOL

Documents:

M. A. Kinna and S. Prosen, "Effective fabrication variables on the filament-wound NOL ring," presented at the 19th Annual SPE Conference, 1963.

Files of the Non-Magnetic Materials Division, NOL.

## RXD Event Description

1. Title: Feasibility Established for Making Reinforced-Plastic Mine Case with Integral Ribs in Single Process (#95)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mine Case (Mine Mk 57)

4. Element:

   a. Mechanism Compartment Mk 2

   b. Explosives Section Mk 2

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event concerns the invention of a means to manufacture reinforced plastic structures with integral ribs in a single noninterrupted process. The mandrel used for this purpose was a special type which incorporated grooves into which the resin-bathed tape was wound to constitute the ribs. When each of the several ribs was completely formed, the cylinder proper was made by winding resin-covered cloth around the mandrel. The entire structure was then cured at an elevated temperature after which the mandrel was collapsed and withdrawn.

   b. Relationship to Contemporary Science and Technology:

Structures that must withstand considerable external pressure and yet must not be excessively heavy often are reinforced by a system of internal ribs. At the time of this event, it was standard practice within the plastics industry to make the tubular shell and the ribs as separate operations and to assemble them later by means of adhesives. To insure that the ribs would contribute to the strength of the shell, it was necessary to control their fit very precisely, prepare their mating surfaces very carefully, and cure the bond very systematically. The process was long, tedious, and costly. It was always vulnerable to operator error because of the large amount of labor that it entailed. By this event a system was provided wherein the ribs and shell were formed in one continuous process.

Prepared By: W. T. Johnson, NOL (WO) Date: 3 Mar 66

5. Technical Significance:- Continued:

c. Relationship to Succeeding Development or to System Performance:

This event improved the strength of the plastic case for mine Mark 57, made it uniformly reproducible, and reduced its cost.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

F. R. Barnet, Chemical Engineer, in charge of Non-metallic Materials Division, NOL. Recognized the benefits to be achieved by making the ribs integral with the shell. Designed the collapsible mandrel, had it fabricated, and demonstrated its practicality with a series of prototype structures.

W. T. Johnson, Engineering Technician, Non-metallic Materials Division NOL. Worked with Barnet on this event and shares with him the patent.

8. Date of Event:

a. Termination: 1956

b. Initiation: 1956

9. Duration: Six months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Chemistry Research Department

c. Non-metallic Materials Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds

12. Financial Support:- Continued

b. Duration- Six months

c. Amount- Estimated $25,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in the mine Mark 57 and in a variety of other programs, including Polaris. Additional advances were later made in techniques and materials for light-performance plastic structures.

b. Previous Activity:

It was highly desired that the mine case for the mine Mark 57 be made of plastic to insure its compatibility with its firing system. The stringent depth and endurance requirements imposed upon this weapon made it necessary to advance the state of the art of plastic structures manufacture. In particular, this event resulted in a structure that developed the full potential of the reinforcing ribs by making their interface with the shell a perfect fit.

14. RXD Event Circumstances:

NOL was interested in extending the use of reinforced plastics into all areas that might profit from the unique qualities of this material. A pilot facility and supporting shops were available at NOL which permitted the necessary experimentation with various resins, finishes, cloths, and techniques.

15. Sources:

Persons Interviewed:

S. Prosen, NOL

S. E. West, NOL

Documents:

Files in the Non-metallic Materials Division, NOL.

# RXD Event Description

1. Title: Use of Roving as Replacement for Tape in Mine-Case Ribs (#96)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mine Case (Mine Mk 57)

4. Element:

   a. Mechanism Compartment Mk 2

   b. Explosive Section Mk 2

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This work concerns the introduction of continuous roving as a replacement for the tape used in the manufacture of integral ribs for reinforced plastic structures.

   b. Relationship to Contemporary Science and Technology:

At the time of this event, the process of making the ribs and wall of a plastic structure in one continuous operation used glass tape as the material for the rib proper. The tape was not well suited for this purpose. Because tape is woven, approximately half of its material lies in line with its length, while the remainder lies normal to this length. The latter is of no value in the application discussed here because the only contributing material is that in line with the plane of the rib. Roving is a continuous bundle of filaments all of which lie in one direction. Its use in this application meant that less material was required to build a structure for a specific strength level and the weight of the structure was correspondingly less than when tape was employed.

   c. Relationship to Succeeding Development or to System Performance:

This event constituted another advance in the manufacture of the reinforced plastic case of the mine Mark 57. Buoyance was of particular importance in this application and this event helped to achieve maximum strength with minimum weight.

Prepared By: F. Robert Barnet, NOL (WO) Date: 3 Mar 66

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

F. R. Barnet, Chemical Engineer in charge of Non-Metallic Materials Division, Chemistry Research Division, NOL. Conceived this event and demonstrated its feasibility.

W. T. Johnson, Engineering Technician, Non-Metallic Materials Division, Chemistry Research Division, NOL. Assisted Barnet.

8. Date of Event:

a. Termination: 1958

b. Initiation: 1958

9. Duration: Two months

10. Organization:

a. 1. Naval Ordnance Laboratory, White Oak

2. Chemistry Research Division

3. Non-Metallic Materials Division

b. 1. Carl N. Beetle Plastics Corporation

11. Organization Type:

a. Government Laboratory

b. Profit Laboratory, Industrial

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds

12. Financial Support:- Continued

b. Duration: Two months

c. Amount- Estimated $60,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in the manufacture of cases for the mine Mark 57. The idea has also found use in other plastic structures where weight limitations must be recognized.

b. Previous Activity:

This event was motivated by the need for a nonmagnetic, electrically resistive case for the mine Mark 57. NOL believed that an all-plastic structure would be ideally compatible with this firing system. This event was one of a series of studies conducted by NOL toward that end. Because maximum strength and maximum buoyancy were coexisting objectives, it was essential that all material employed in the construction of the case be used efficiently. Barnet and Johnson conceived the idea of replacing the tape with roving and proved its advantages by making and testing prototypes at NOL. At the same time, Carl N. Beetle Corporation was making mine cases for NOL and substituted roving in their system at NOL's request.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

F. R. Barnet, NOL

W. T. Johnson, NOL

Documents:

NAVORD Report 2416 (NOL).

NAVORD Report 5705 (NOL).

NAVORD Report 6165 (NOL).

# RXD Event Description

1. Title: Demonstration of Plastic Mine Case Using High-Modulus Cloth as Structural Material (#97)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mine Case (Mine Mk 57)

4. Element:

   a. Mechanism Compartment Mk 2

   b. Explosive Section Mk 2

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event concerns the introduction of glass cloth with uncrimped fibers as the basic material for the construction of reinforced plastic structures for the mine Mark 57.

   b. Relationship to Contemporary Science and Technology:

At the time of this event, the cloth used for this purpose was woven of crimped fibers. The collapse strength and stability of this type of cloth was not sufficiently high for its application. This event advanced the state of the art by providing a markedly stronger and more stable product without an increase in weight.

   c. Relationship to Succeeding Development or to System Performance:

As a result of this event, the design of the case for the mine Mark 57 was made more efficient.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

   C. Lloyd, Chemical Engineer, Non-Metallic Materials Division, NOL.

Prepared By: Marlin A. Kinna, NOL (WO) Date: 4 Mar 66

7. Key Personnel:- Continued

Recognized the potential advantage offered by the use of high-modulus cloth. Made and tested prototype structures in NOL's plastics facility.

W. T. Johnson, Engineering Technician, Non-Magnetic Materials Division, NOL. Worked with Lloyd in this event.

F. R. Barnet, Chemical Engineer, in charge, Non-Metallic Materials Division, NOL. Guided the work of this event and made the decision that all future cases for the mine Mark 57 would be made with this type of cloth.

8. Date of Event:

a. Termination: 1956

b. Initiation: 1957

9. Duration: Twelve months

10. Organization:

a. 1. Naval Ordnance Laboratory, White Oak

2. Chemistry Research Department

3. Non-Metallic Materials Division

b. P. J. Stevens Company, Incorporated

11. Organization Type:

a. Government Laboratory

b. Profit Laboratory, Industrial

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds

b. Duration- Twelve months

12. Financial Support:- Continued

c. Amount- Estimated $15,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in the mine Mark 57. The disclosures were revised to require the use of this type of cloth in all future manufacture. The event has been reflected throughout the plastics industry in applications demanding maximum strength and stability.

b. Previous Activity:

This event was motivated by the emphasis placed on achieving maximum strength and maximum buoyancy. NOL wished to use a cloth with uncrimped fibers to gain the full strength and stability promised by such a cloth. This type of high-modulus cloth was obtained from the P. J. Stevens Company and used by NOL in its plastics facility in a series of test panels. Case prototypes were later made and tested. The results were very gratifying.

14. RXD Event Circumstances:

Cloth woven from uncrimped fibers was not available before this event. NOL was aware of the potential advantages offered by such a cloth and requested the P. J. Stevens Company to make a pilot order.

15. Sources:

Persons Interviewed:

F. R. Barnet, NOL.

W. T. Johnson, NOL.

M. A. Kinna, NOL.

# RXD Event Description

1. Title: Development of Epoxy Resins for Improved Underwater Endurance (#98)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mine Case (Mine Mk 57)

4. Element:

   a. Mechanism Compartment Mk 2

   b. Explosive Section Mk 2

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event concerns the reformulation of epoxy resins for a new use as the matrix material for reinforced plastics.

   b. Relationship to Contemporary Science and Technology:

At the time of this event, the resins used by the reinforced-plastics industry for low-pressure laminates were of the polyester and phenolic types. Epoxies were used solely as adhesive and coating materials. In attempting to design a plastic case for the mine Mark 57, NOL found that polyesters and phenolics were totally inadequate. They were quite satisfactory in a benign environment but very poor when used in structures that had to survive long-term submergence in sea water. For example, it was apparent that the molecular linkages of polyesters would hydrolyze and degrade to a point at which almost all mechanical strength would be lost. NOL believed that an epoxy could be formulated for use as a matrix for reinforced plastics, and was successful in adapting them for this use. This development by NOL opened the door to the wide use of epoxies as a laminating material. It had a major impact on the reinforced-plastics industry and made epoxies the primary laminating resins in use today.

Prepared By: F. Robert Barnett, NOL (WO) Date: 4 Mar 66

5. Technical Significance:- Continued:

c. Relationship to Succeeding Development or to System Performance:

This event improved the general system performance by contributing to its strength and high-performance requirements. It also helped to lower the cost. Because epoxies permit some latitude in their use and are relatively tolerant of operator variations, they are well suited for large-quantity, low-cost production.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

I. Silver, Chemist, Chemistry Division, Engineering Department, NOL. Conceived the idea that epoxies could be reformulated for use as matrix material for plastic laminates and carried out the necessary work in NOL's plastics facilities.

H. B. Atkinson, Jr., Chemical Engineer, Chemistry Division, Engineering Department, NOL. Shared Silver's ideas and worked closely with him on this event.

8. Date of Event:

a. Termination: 1950

b. Initiation: 1960

9. Duration: Six months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Engineering Department

c. Chemistry Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Navy (Bureau of Ordnance) funds

12. Financial Support:- Continued

b. Duration- Six months

c. Amount- Estimated $5,000

13. System Interface Activity:

a. Comtemporary and Succeeding Activity:

This event, together with related innovations, made possible the successful development of the all-plastic case for mine Mark 57. By NOL's work, certain epoxy formulations were established which permitted their use as a laminating material. This family of resins is now widely used throughout the world for high-strength structural laminations, both military and commercial. Epoxy formulations based on NOL's work are used in the manufacture of rocket launchers, missile parts, and oblating heat shields. Commercial uses are extensive and include such highly critical applications as tanks, towers, and piping for the chemical processing industry.

b. Previous Activity:

This event was essential to the development of a nonmagnetic, electrically resistive case for the mine Mark 57. This case had to have maximum strength and stability and be able to maintain these qualities for extended periods of time at great depths in seawater. Also, because the case had to have maximum buoyancy, it was essential that the materials used in its construction be optimum for this purpose. It was mandatory that a breakthrough in the plastics industry be accomplished in order that plastics could be used for this demanding application. NOL's applied research in adhesives solution. Existing epoxy formulations were not directly applicable, but NOL was successful in reformulating them for this new use.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

P. W. Ericson, NOL

I. R. Barnett, NOL

15. Sources:- Continued:

Documents:

"Epoxy Resins in Glass-Cloth Laminence," Modern Plastics, Nov. 1960.

Miscellaneous NOL papers relating to research and development in composition materials.

## RXD Event Description

1. Title: Adaptation of Plastic Premix To Replace Laminate for Structure Segments (# 99)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Mine Case (Mine Mk 57)

4. Element: Mechanism Compartment Mk 2

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the introduction of a special high-strength molding compound to solve a problem of delamination experienced by previous materials. The material is known as Scotchply 1100.

b. Relationship to Contemporary Science and Technology:

In the case for the mine Mark 57, the arresting blocks used to secure the firing system and its power supply are made of plastic. The initial design used a low-pressure glass-cloth laminate, but it was found that this material tended to delaminate under shock loads. The new random-oriented, fiber-filled molding compound, Scotchply 1100, showed superior qualities as an arresting block material. The fact that this material used random fibers made its tensile strength approximately twice that of any other molding compound. This event and other related innovations measurably advanced the state of the art of reinforced plastics.

c. Relationship to Succeeding Development or to System Performance:

This event improved the general system performance by providing a mine case fully compatible with the critical firing system and capable of surviving deep submergence in seawater for long periods of time.

6. Type of RXD Event: Exploratory Development

Prepared By: Toy A. Ng, NOL(WO) 4 Mar 66

7. Key Technical Personnel:

F. R. Barnett, Chief, Non-Metallic Materials Division, Chemistry Research Department, NOL. Directed the work of Mathews and Ng.

H.E. Mathews, chemist, Non-Metallic Materials Division, Chemistry Research Department, NOL. Conceived and demonstrated the event, together with Ng.

Toy A. Ng, mechanical engineer, Non-Metallic Materials Division, Chemistry Research Department, NOL. Responsible for solving the delamination problem. Worked with Mathews on the event.

8. Date of Event:

a. Termination: 1963

b. Initiation: 1963

9. Duration: Five weeks

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Chemistry Research Department

c. Non-Metallic Materials Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source-Navy (Bureau of Navy Weapons) funds

b. Duration-Five weeks

c. Amount-Estimated $2,000.

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

The disclosures for the mine Mark 57 now require the use of the material introduced by this event.

b. Previous Activity:

During prototype evaluation of the original design which used arresting blocks made of glass-cloth laminates, these blocks were found to delaminate under shock loads. Because this discovery was made rather late in the program, redesign options were rather limited. Mathews and Ng believed they could solve the problem without need to reconfigure the blocks. They did this by using the newly introduced Scotchply 1100. They experimented with its use, designed compression molds, and made prototypes for tests. These tests established its superiority over the previous material.

14. RXD Event Circumstances:

It would have been possible, of course, for NOL to use a metal-arresting block to solve the delamination problem experienced with the glass-cloth design. However, the presence of metals even nominally nonmagnetic would have violated the restrictions imposed upon this design. NOL was determined to satisfy this requirement and, therefore, sought a plastic replacement that was less likely to delaminate under shock. Fortunately, Scotchply 1100 had just appeared on the market and was available for this use.

15. Sources:

Persons Interviewed:

H. E. Mathews, NOL.

T. A. Ng, NOL.

Documents:

NOL Notebook No. 96-5441

## RXD Event Description

1. Title: Development of Low-Drain Transistor Flip-Flops of the Nonsaturating Type for Total Field Magnetic Influence Mine Firing System (#30)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Actuation (Magnetic Influence)

4. Element: Firing Mechanism Mk 26, Total Field Magnetic Logic Circuitry

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event involved the conception and feasibility demonstration of nonsaturating-type flip-flops operating in the microwatt power range.

   b. Relationship to Contemporary Science and Technology:

At the time of this event, memory and timing circuits had been devised to operate at low power. In the application of these circuits at the power levels consistent with long mine life, instabilities were encountered with available flip-flops. This event provided flip-flops that would operate with microwatt power and yet be stable enough for reliable performance.

   c. Relationship to Succeeding Development or to System Performance:

Without this event, mine-firing systems with adequate countermeasures resistance would demand so much energy that their effective life would be unacceptably short. This situation, if tolerated, would require the frequent replenishment of mines in order to maintain a desired level of threat. By means of this event, the power requirement was reduced to a level that permitted an effective mine life of many months.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

H. Lefkowitz, electronics engineer, Magnetics and Electrical Division, Underwater Ordnance Department, NOL. Conducted the analytical study.

Prepared by: Armand Cioccio, NOL (WO) Date: 12 Feb 66

7. Key Personnel:- Continued:

A. Cioccio, Electronics Engineer, Magnetics and Electrical Division, Underwater Ordnance Department, NOL. Carried out an experimental investigation that culminated in the design of stable and useful flip-flops for mine applications.

6. Date of Event:

a. Termination: 1956

b. Initiation: 1956

9. Duration: Six months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Magnetics and Electrical Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds

b. Duration: Six months

c. Amount: Estimated $20,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

Laboratory and field tests demonstrated that the new flip-flops would operate for many months with only a minimal drain on the mine's power supply. They have been used in all production of the firing mechanism Mark 26 for the moored mines Mark 56 and 57.

13. System Interface Activity:- Continued:

b. Previous Activity:

It is imperative that any firing system intended for use in naval mines must operate at very low power so that the effective life of the weapon is adequately long. It is equally important that the firing system be capable of distinguishing between legitimate targets and decoys so that sweeping efforts by the enemy cannot dispose of them. These combined objectives can be served only if the intelligence functions of the system can operate at extremely low power. Solid-state memory and timing circuits had been introduced for this purpose. However, the flip-flops used in these circuits proved insufficiently stable when operated under the available power level. NOL was therefore motivated to provide more stable devices capable of proper operation in the microwatt range.

14. RXD Event Circumstances: None

15. Sources:

NOL reports and memoranda pertaining to total field influence firing mechanism Mark 26 Model 0.

# RXD Event Description

1. Title: Use of Film Resistors To Achieve Long-Term Storage Life for Total Field Magnetic Influence Mine Firing System (#33)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Actuation (Magnetic Influence)

4. Element: Firing Mechanism Mk 26, Total Field Magnetic, Logic Circuitry

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the substitution of resistors with extremely stable characteristics for the composition resistors which proved to degrade with age.

b. Relationship to Contemporary Science and Technology:

At the time of this event, the gradual degradation of the composition resistors used in the firing mechanism Mark 26 was causing a loss of sensitivity that tended to prevent the mechanism from responding to targets having weak magnetic signals. This event solved the problem with the use of more stable resistors of the film type.

c. Relationship to Succeeding Development or to System Performance:

This event improved the general system performance by preventing the premature aging of the firing mechanism Mark 26 and increasing the shelf life of the device fivefold or more.

6. Type of RXD Event: Advanced Development

7. Key Personnel:

A. W. Obenschain, electronics engineer, Magnetics and Electrical

Prepared By: Armand Cioccio Date: 7 Mar 66

7. Key Personnel:- Continued

Division, NOL. Headed the team that studied and solved this problem.

R. O. Wales, electronics engineer, Magnetics and Electrical Division, NOL. Team member.

H. Lefkowitz, electronics engineer, Magnetics and Electrical Division, NOL. Team member.

A. Cioccio, electronics engineer, Magnetics and Electrical Division, NOL. Team member.

8. Date of Event:

a. Termination: 1958

b. Initiation: 1959

9. Duration: Six weeks.

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Electrical Engineering Department

c. Magnetics and Electrical Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds.

b. Duration- Six Weeks

12. Financial Support:- Continued

c. Amount- Estimated $5,000.

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in the firing mechanism Mark 26.

b. Previous Activity:

During the evaluation of the total field magnetic influence firing mechanism Mark 26, it would found that the characteristics of the mechanisms were changing with time at a rate that would have limited their shelf life to only two years or so. Studies by NOL revealed that the primary cause of this deterioration was the fact that the composition-type resistors were varying and drifting with age. Fortunately, film resistors which were functionally preferable but which had not been used earlier because of their high cost, were by this time more economical; therefore, they were substituted in each instance where the resistance value was critical.

14. RXD Event Circumstances:

Because approximately 160 resistors are used in the firing mechanism Mark 26, the unit cost of these resistors is a significant design consideration. Initially, composition resistors rather than film resistors were selected because of a 50-to-1 difference in cost. Fortunately, the quantity production of film resistors had--by the time of this event--reduced their cost by an order of magnitude. This made their use economically feasible, and the design of the mechanism was upgraded.

15. Sources:

Documents:

NOL reports and memoranda pertaining to the firing mechanism Mark 26 Model O.

RXD Event Description

1. Title: Development of Low-Frequency Coupling Circuit for Optimally Flat Signal Response for Total Field Magnetic Influence Mine Firing System (#24)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Actuation (Magnetic Influence)

4. Element: Firing Mechanism Mk 26, Total Field Magnetic, Circuitry

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the theoretical study and development of a very low-frequency filter and derivative circuit to provide proper mine response to targets travelling at different speeds. In essence, this circuit takes the derivative of the amplified output of the magnetometer and provides a signal to the memory circuitry of the firing mechanism. By this arrangement, the response of the mechanism was made less dependent upon the speed of the target. The variations of target sensitivity with target transit times within the range of 10 to 120 seconds was reduced by a factor of two.

b. Relationship to Contemporary Science and Technology:

By this event, the total field magnetic influence firing mechanism Mk 26 for the mines Mk 56 and Mk 57 was made less dependent upon target speed than was possible with the previous capacitive coupling circuit.

c. Relationship to Succeeding Development or to System Performance:

This event improved the general system performance by substantially increasing the distance at which a slow-moving target would actuate the mines.

6. Type of RXD Event: Exploratory Development

Prepared By: Armand Cioccio, NOL(WO) Date: 2 Mar 66

7. Key Personnel:

J.K. Robinson, Electronics Engineer, Advanced Development Group, Radio Corporation of America. Responsible for the initial studies relative to the low-frequency coupling circuit.

H.M. Frazier, Electronics Engineer, Magnetics and Electrical Division, Underwater Ordnance Department, NOL. Continued this work and established a coupling circuit with an optimally flat signal response.

8. Date of Event:

a. Termination: 1956

b. Initiation: 1956

9. Duration: Ten months

10. Organization:

a. 1. Radio Corporation of America

2. Advanced Development Group

b. 1. Naval Ordnance Laboratory, White Oak

2. Underwater Ordnance Department

3. Magnetics and Electrical Division

11. Organization Type:

a. Profit Laboratory, Industrial

b. Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) in-house funds and funds under Contract Number NORD 13084.

b. Duration- Ten months

c. Amount- Estimated $35,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in the mines Mk 56 and Mk 57.

b. Previous Activity:

The warheads of the mines Mk 56 and Mk 57 are able to do significant damage even when fired at a considerable distance from a ship or submarine. It is advantageous to have the firing mechanism able to respond to the target at the maximum damage distance--regardless of the speed of the target. Before this event, a magnetic influence firing system would not respond against a slow-moving target until the distance had been closed to considerably less than the damage range. This inadequacy motivated NOL to seek a system that would make the firing range for slow-moving targets more nearly equal to the damage range. Contract NORD 13084 had been placed with RCA for the manufacture of evaluation models of the initial (vacuum-tube) design of the total field magnetic influence firing system. When NOL field tests in 1954 revealed that the system was too dependent upon target speed, RCA was requested to study and develop a circuit which would improve the response characteristics of the mine. By 1956 NOL succeeded in refining the circuit and made it available for use in production.

14. RXD Event Circumstances: None

15. Sources:

Documents:

Contract NORD 13084, Final Report on the Mine Firing Mechanism XM4B, April 1955.

NOL Files and Memoranda pertaining to Firing Mechanism Mk 26 Model 0.

## RXD Event Description

1. Title: Invention of Ring Modulator and Pulse Amplifier To Replace Magnetic Amplifier in Total Field Magnetic Influence Mine Firing System (#23)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Actuation (Magnetic Influence)

4. Element: Firing Mechanism Mk 26, Total Field Magnetic, Circuitry

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the invention and development of a highly sensitive modulator, using newly developed silicon diodes, to replace the magnetic amplifier in the total field magnetic firing system for moored mines.

b. Relationship to Contemporary Science and Technology:

At the time of this event, manufacturing problems were being experienced with the magnetic amplifier specified for the firing mechanism. These included shock vulnerability, balance difficulties and degradation with age. Altogether, they resulted in an unacceptably low yield and intolerably high cost. The requirements imposed by the overall system taxed the state of the art of magnetic materials technology. By this event a design was produced which operated on minimum power and was stable and sufficiently rugged for use under the conditions of high shock associated with air-laid ordnance. This was the first successful application of a ring modulator and pulse amplifier operating in the microwatt range.

c. Relationship to Succeeding Development or to System Performance:

This event removed a production handicap and made possible the high-rate, economical manufacture of the total field magnetic influence firing mechanism Mk 26 for the mines Mk 56 and Mk 57.

6. Type of RXD Event: Exploratory Development

Prepared By: Armand Cioccio, NOL (WO) Date: 28 Feb 66

7. Key Personnel:

T.E. Lindsay, Electronics Engineer, Advanced Development Group, Radio Corporation of America (RCA). Responsible for the conception of a microwatt ring modulator; recognized as its inventor.

W.C. Folz, Electronics Engineer, Magnetics and Electrical Division, Underwater Ordnance Department, Naval Ordnance Laboratory (NOL). Responsible for the introduction of the pulse amplifier which co-acted with the ring modulator to constitute a replacement for the magnetic amplifier.

H. Lefkowitz, Electronics Engineer, Magnetics and Electrical Division, Underwater Ordnance Department, NOL. Same responsibility as Folz.

A. Cioccio, Electronics Engineer, Magnetics and Electrical Division, Underwater Ordnance Department, NOL. Same responsibility as Folz.

8. Date of Event:

a. Termination: 1954

b. Initiation: 1954

9. Duration: Six months

10. Organization:

a. 1. Radio Corporation of America

2. Advanced Development Group

b. 1. Naval Ordnance Laboratory, White Oak

2. Underwater Ordnance Department

3. Magnetics and Electrical Division

11. Organization Type:

a. Profit Laboratory, Industrial

b. Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) in-house funds an funds under Contract Number NORD 13084.

b. Duration - Six months

c. Amount– Estimated $30,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in the mines Mk 56 and Mk 57.

b. Previous Activity:

The difficulty experienced with the magnetic amplifier was the motivation that led NOL to seek an alternative that would allow a higher rate of production and, if possible, be superior in performance. The problems were so severe that NOL decided to investigate a new circuit using solid-state devices. Under direction by NOL, RCA was requested to study the feasibility of using such devices to replace the magnetic amplifier. RCA recommended the use of a ring modulator and built a breadboard. NOL added a pulse amplifier to the circuit which, with the ring modulator, constituted a complete replacement of the magnetic amplifier.

14. RXD Event Circumstances:

The cost of making a magnetic amplifier of a quality necessary for this application had increased several fold because of the high rejection rate. RCA and

14. RXD Event Circumstances: - Continued

NOL, acting in cooperation, were able to replace this critical item by a ring modulator-pulse amplifier combination at one-tenth the former cost.

15. Sources:

Documents:

Contract NORD 13084, Final Report Relating to Mine Firing Mechanism XM-4B.

NOL Files and Memoranda Relating to Firing Mechanism Mk 26 Mod 0.

# RXD Event Description

1. Title: Development of a Filter Circuit To Prevent Switch Chatter from Dudding a Mine (#32)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Actuation (Magnetic Influence)

4. Element: Firing Mechanism Mk 26, Total Field Magnetic, Logic Circuitry

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the conception and demonstration of a filter circuit which prevents a momentary interruption in the supply voltage to the firing mechanism mixer from causing a dud mine.

b. Relationship to Contemporary Science and Technology:

At the time of this event, if the cam action in the actuation counter Mk 10 Mod 1 was somewhat rough, the supply voltage to the firing mechanism Mk 26 could be momentarily interrupted. This, in turn, would remove voltage from a relay in the counter and prevent complete operation of the latter. If the counter could not complete its cycle, the firing mechanism would be unable to receive further target signals. This event provided a simple capacitor-resistor circuit which stores enough energy to guarantee a complete cycling of the actuation counter.

c. Relationship to Succeeding Development or to System Performance:

This event improved the general system performance by providing a capable, reliable, and inexpensive means to smooth the voltage and prevent dudding of the mine.

6. Type of RXD Event: Advanced Development

Prepared By: Armand Cioccio, NOL(WO) Date: 495-7266

7. Key Personnel:

A. Cioccio, Electronics Engineer, Magnetics and Electrical Division, Underwater Electrical Engineering Department, NOL. Conceived the idea of the filter circuit.

W.C. Folz, Electronic Engineer, Magnetics and Electrical Division, Underwater Electrical Engineering Department, NOL. Conducted the tests and demonstrated the feasibility of the idea.

8. Date of Event:

a. Termination: 1959

b. Initiation: 1959

9. Duration: One month

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Electrical Engineering Department

c. Magnetics and Electrical Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds.

b. Duration- One month

c. Amount- Estimated $5,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in all production of the total field magnetic influence firing mechanism Mk 26 for the moored mines Mk 56 and Mk 57.

b. Previous Activity:

The firing mechanism Mk 26 receives target signals and responds to these signals by operating a ship-counting device called an actuation counter. The latter can be preset to require a large number of actuations before it allows the firing mechanism to explode the mine. Unless extreme care is taken, at considerable expense, to control the surface finish of the cam in the counter, the cam follower can fail to track and can thereby cause an open circuit for as long as 80 milliseconds. This momentary interruption will stop the counter cycle and block further operation of the system. This motivated NOL to seek a solution which would prevent loss of the mine.

14. RXD Event Circumstances:

Another solution to this problem might have been the provision of the tighter tolerance controls on the actuation counter. This would have resulted in higher cost and might not have proved entirely successful.

15. Sources:

Documents:

NOL reports and memoranda pertaining to firing mechanism Mk 26 Model 0.

## RXD Event Description

1. Title: Demonstration of Using Diodes and Transistors for Memory and Timing Circuits of Total Field Magnetic Influence Mine Firing System (#27)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Actuation (Magnetic Influence)

4. Element: Firing Mechanism Mk 26 Total Field Magnetic, Logic Circuitry

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the feasibility demonstration of memory and timing circuits which permitted the design of a low-power and therefore long-life mine-firing mechanism with a sophisticated ability to discriminate between legitimate targets and decoys.

b. Relationship to Contemporary Science and Technology:

At the time of this event, only hot filamentary and cold cathode tubes were available to perform intelligence functions in mine firing mechanisms. Because of the high energy drain, only elementary circuits could be used. As a consequence, the mines were vulnerable to countermeasures and had relatively short endurance. The development of low-power, solid-state devices by the Bell Telephone Laboratories dramatically changed this situation. This event permitted the application of their new devices in the development of a series of semi-conductor circuits to perform primary timing and logic functions for naval mines.

c. Relationship to Succeeding Development or to System Performance:

This event improved the general system performance by increasing the intelligence and endurance of mine firing mechanisms.

6. Type of RXD Event: Exploratory Development

Prepared By: Armand Cioccio, NOL(WO) Date: 14 Feb 66

7. Key Personnel:

B.M. Oliver, Electronics Engineer, Transistor Applications Group, Bell Telephone Laboratories. Responsible for the conception and feasibility demonstration of the memory and timing circuits.

8. Date of Event:

a. Termination: 1951

b. Initiation: 1951

9. Duration: Four months

10. Organization:

a. Bell Telephone Laboratories

b. Transistor Applications Group

11. Organization Type: Profit Laboratory, Industrial

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds under Contract Number NORD 12107.

b. Duration- Four months

c. Amount- Estimated $40,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

The circuits made available by this event were subsequently incorporated into the design of a countermeasures-resistant mine-firing system for the mines Mk 56 and Mk 57.

13. System Interface Activity: - Continued

b. Previous Activity:

To be effective, a mine must be able to resist enemy efforts to decoy it and must remain a threat for a long time after planting. NOL was anxious to improve the countermeasures resistance and useful life of mines. Recognizing that solid-state devices could be used in mine intelligence circuits, NOL directed the Bell Telephone Laboratories to undertake the development of fundamental timing and logic circuits.

14. RXD Event Circumstances: None

15. Sources:

Documents:

Contract NORD 12107: Final report on mine firing mechanism circuits, by Bell Telephone Laboratories.

NOL reports and memoranda pertaining to firing mechanism Mk 26 Mod 0.

RXD Event Description

1. Title: Incorporation of Getter in Transistors To Solve $I_{CO}$ and "Sleeping Sickness" Problem (#34)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Actuation (Magnetic Influence)

4. Element: Firing Mechanism Mk 26, Total Field Magnetic, Logic Circuitry

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the addition of a "getter" within the envelope of the grown-junction transistor to absorb gaseous impurities.

b. Relationship to Contemporary Science and Technology:

At the time of this event, the grown-junction transistor 2N167A used in the total field magnetic influence firing system tended to degrade in two respects: it exhibited a gradual increase in $I_{CO}$, called nuisance current, which lowered the efficiency of the transistor; and it was susceptible to "sleeping sickness" or sloppy cut-off. These two defects resulted in an instability in the flip-flops used in the firing mechanism mixer. This event established that the defects were caused by the presence of vapors within the transistor envelope and provided a solution in the form of a vapor adsorber.

c. Relationship to Succeeding Development or to System Performance:

Use of the getter improved the general system performance by adsorbing the vapors responsible for the degradation of the transistors.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

A. Cioccio, Electronics Engineer, Magnetics and Electrical Division, Underwater Electrical Engineering Department, NOL. Identified the firing system problem and deduced its cause.

Prepared By: Armand Cioccio Date: 4 Mar 66

7. Key Personnel:- Continued

R. Stasior, Semiconductor Product Department, General Electric Company. In charge of grown-junction transistor developments, he introduced the getter as a means to adsorb the vapors in the transistor envelope.

8. Date of Event:

a. Termination: 1959

b. Initiation: 1959

9. Duration: Four months

10. Organization:

a. 1. Naval Ordnance Laboratory, White Oak

2. Underwater Electrical Engineering Department

3. Magnetics and Electrical Division

b. 1. General Electric Company

2. Semiconductor Product Department

11. Organization Type:

a. Government Laboratory

b. Profit Laboratory, Industrial

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds

b. Duration- Four months

c. Amount- Estimated $20,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

The getter proposed by the General Electric Company was proven capable of adsorbing the vapors responsible for the degradation of the transistors. Getters are now used in all grown-junction type transistors.

b. Previous Activity:

The problems of "sleeping sickness" and creeping $I_{co}$ were first encountered with transistors in the early 1950's. In 1956 NOL introduced a transistorized mixer using flip-flops as part of the total field magnetic influence firing system. In this application, these defects proved to be serious and the need for a solution was imperative. NOL tested several hundred transistors and identified the cause.

14. RXD Event Circumstances: None

15. Sources:

Document:

NOL reports and memoranda pertaining to firing mechanism Mark 26 Model 0.

RXD Event Description

1. Title: Demonstration of Simultaneous Weaving of Several Broad-Width Ribbons for Parachute Canopy (#110)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Flight Gear (Mines Mk 56)

4. Element: Ring Slot Parachute Mk 29

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the adaptation of an existing manufacturing technique to permit the simultaneous weaving of multiple ribbons on a single loom to reduce the cost of parachute canopies.

b. Relationship to Contemporary Science and Technology:

At the time of this event, the weaving of narrow fabrics was generally limited to widths much less than the 11 inches required by the unrestricted ring slot parachute canopy design. The use of broad looms (30 to 40 inches wide) to weave narrow fabrics wasted the capacity of the loom because only a single ribbon could be produced. This event made it possible to produce four ribbons simultaneously on a broad loom with a false or dupe selvedge on the interior ribbon edges, thereby using the full capacity of the loom.

c. Relationship to Succeeding Development or to System Performance:

Since looms weave at a constant rate, the ability to weave several ribbons simultaneously provides an economical method of producing ribbons of 8 inches or more in width. The price of parachute canopies constructed of ribbons was thereby markedly reduced. This event improved system performance by reducing the cost of the unrestricted ring slot parachute. Because this parachute was capable of surviving inflation at speeds higher than was possible with any other design, it was cited

Prepared By: Leon J. Lofthus Date: 12 Mar 66

5. Technical Significance:- Continued

for use by a number of weapons systems.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

G. L. Sloan, mechanical engineer, Flight Gear Section, Weapon Mechanisms Division, Underwater Ordnance Department, NOL. Conceived this event in consultation with Harris.

G. G. Harris, Newmarket Manufacturing Company. Experienced in the manufacture of textiles before serving in the Navy during World War II, he was assigned to NOL's Flight Gear Section at that time and provided a useful link between NOL's parachute designers and the textile industry. After he left the Navy, he continued his association with the Laboratory and provided assistance in the manufacture of new fabrics for parachute use. Responsible for samples of fabric in this event.

8. Date of Event:

a. Termination: 1952

b. Initiation: 1952

9. Duration: One month.

10. Organization:

a. Naval Ordnance Laboratory, White Oak (NOL)

b. Underwater Ordnance Department

c. Weapon Mechanisms Division

d. Flight Gear Section

10. Organization:- Continued

e. Newmarket Manufacturing Company

11. Organization Type:

a. Government Laboratory

b. Profit Laboratory, Industrial

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds.

b. Duration- One month

c. Amount- Estimated $12,000.

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in the design of the unrestricted ring slot parachute Mark 29. It is now the standard method for the manufacture of heavy, wide ribbons for parachute canopies.

b. Previous Activity:

The unrestricted ring slot parachute employs wide (11-inch) ribbons to form concentric circles to comprise a parachute canopy, starting at the hem and continuing to the apex in parallel hoops of decreasing diameter. Wide ribbons provide stability to the canopy without the need for additional vertical (hem-to-apex) stringers, as had been required by earlier ring slot parachute designs. The fact that this design would be made in large quantities motivated NOL to study the possibilities of cost reduction. The multiple weaving of the wide ribbon appeared to be feasible. Sloan and Harris conceived

13. System Interface Activity:- Continued

the idea of arranging the wide ribbons in parallel across the width of the loom and using false selvedges between them to permit their simultaneous weaving. Harris converted existing equipment at Newmarket and produced a pilot run of experimental ribbons. These ribbons were used at NOL in the manufacture of prototype parachutes.

14. RXD Event Circumstances:

Although this parachute design could have been manufactured if this event had not occurred, its cost would have been appreciably greater.

15. Information Sources:

G. L. Sloan, NOL.

W. P. Ludtke, NOL.

RXD Event Description

1. Title: Introduction of Potential Theory To Extrapolation of a Ship's Magnetic Field by Use of High-Speed Digital Computers (#126)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem:

   a. Overall

   b. Actuation (Magnetic Influence)

4. Element:

   a. Target Analyses

   b. Firing Mechanism Mk 26, Total Field Magnetic

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event concerns the establishment of a means for the rapid and economical evaluation of a mine's response to a target by computer techniques. A theorem of potential theory states that, if the normal component of the magnetic field of an object is known at all points on a surface surrounding the object, then the magnetic field of the object can be calculated at any point outside the surface. The surface employed is a hemisphere of infinite radius, the plane of which passes under and close to the ship. Measurements of the vertical magnetic field in this plane provide the data used as input to a high-speed digital computer, which then performs the integrations necessary to obtain the three components of the ship's magnetic field in planes below the plane of the measurements. These calculated fields are used in the evaluation of all magnetic naval mines by determining their responses to the various classes of ships.

   b. Relationship to Contemporary Science and Technology:

At the time of this event, the generation of extensive data by hand methods

Prepared By: R. H. Ryswick, NOL (WO) Date: 11 Mar 66

5. Technical Significance:- Continued

would have been laborious, expensive, and time consuming. This event greatly facilitated the determination of mine response characteristics. Used in conjunction with other digital computer programs which simulate mine response, it permits their complete evaluation.

c. This event contributed to the efficiency by which data pertaining to a mine's capabilities is made available to the fleet. The entire extrapolation of a target's magnetic field can now be performed by digital computer, with a consequent saving of time and money.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

R. H. Ryswick, Physicist, Electrical Evaluation Division, Underwater Evaluation Department, NOL. Conceived and demonstrated the feasibility of evaluating mine response by means of digital computers. Had 10 years' experience in mine evaluation and mine field studies.

8. Date of Event:

a. Termination: 1962

b. Initiation: 1962

9. Duration: Approximately six months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Evaluation Department

c. Electrical Evaluation Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds

b. Duration- Six months

c. Amount- Estimated $15,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in the mines Mark 56 and Mark 57 and in the evaluation of all magnetic naval mines.

b. Previous Activity:

The Naval Ordnance Laboratory has full responsibility for the design, development, and evaluation of naval mines. It is essential that the Mine Planning Office be fully informed regarding the response of each type of mine to the many classes of ships and submarines that constitute targets. With this information, it can design a mine field to best serve the purposes of a blockade or attrition in terms of the probable traffic. This event came about as the result of a continuing effort to improve the speed, economy, and accuracy of laboratory mine evaluation.

14. RXD Event Circumstances: None

15. Sources:

Documents:

NOL reports and memoranda pertaining to potential theory as applied to extrapolation of a ship's magnetic field.

## RXD Event Description

1. Title: Establishment of Facility and Techniques for Studying and Measuring Magnetic Fields of Submarines (#127)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem:

   a. Overall

   b. Actuation (Magnetic Influence)

4. Element:

   a. Target Analyses

   b. Firing Mechanism Mk 26, Total Field Magnetic

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event involved the establishment of a test range in the sea to measure the magnetic fields of ships and submarines for subsequent laboratory studies and simulation work.

   b. Relationship to Contemporary Science and Technology:

The development of increasingly sensitive and discriminating magnetic influence mechanisms produced new problems in detecting and recording small magnetic fields. The recording of ship and submarine magnetic fields had previously been relegated to a minor role in the process of degaussing and deperming. The sensitivity and detail of these recordings, together with the process of reducing these data into a form which could be used by high-speed digital computers, was not required for earlier mine development programs. With improved methods of data processing, analysis of the earlier data revealed inadequacies of the older systems, and a new type or range was therefore

Prepared By: P. L. Dobak Date: 15 Mar 66

5. Technical Significance:- Continued

constructed off New London. The new range avoided the technical shortcomings of previous ranges.

c. Relationship to Succeeding Development or to System Performance:

The quality of data obtained from the new range made possible more accurate evaluation of existing mine mechanisms and permitted the development of ultra-discriminating magnetic influence mechanisms such as those used in the mines Mark 56 and Mark 57.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

H. E. Wolf, physicist, Electrical Evaluation Division, Underwater Evaluation Department, NOL. With 23 years' experience in mine-actuation analysis, he was one of the NOL team that conceived and directed the construction of the new and unique range at New London.

R. H. Ryswick, physicist, Electrical Evaluation Division, Underwater Evaluation Department, NOL. Part of the NOL team responsible for this event. Had 10 years' experience in mine-actuation analysis.

P. L. Dobak, physicist, Electrical Evaluation Division, Underwater Evaluation Department, NOL. Part of the NOL team. Had 6 years' experience in data acquisition, recordings of small magnetic fields, and reduction of such data for digital computers.

8. Date of Event:

a. Termination: 1962

b. Initiation: 1962

9. Duration: Six months.

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Evaluation Department

c. Electrical Evaluation Division

d. System Evaluation Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds under Task Assignment CM12-M1000/212-1/F108-08-10 Problem 136: Fleet Operational Data, Mine Mechanisms (U).

b. Duration- Six months

c. Amount- 1,500,000.

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

By means of this event basic data were recorded for subsequent extrapolation and use at NOL. By an associated event, the use of potential theory was demonstrated to be feasible for the extrapolation of ship and submarine magnetic fields using high-speed computers.

b. Previous Activity:

Mine characteristics and capabilities were prepared for fleet use by NOL, which had cognizance of all phases of mine development and evaluation for the Bureau of Naval Weapons. This program was initiated to meet requirements for greater detail and accuracy of such evaluations. The NOL team surveyed potential areas for the installation of the special test facility and selected the New London site because of its excellant

13. System Interface Activity:- Continued

hydrographic conditions and the fact that submarines could be ranged as they entered and left the nearby base.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

H. E. Wolf, NOL.

Documents:

NOL reports and memoranda pertaining to New London test range for measuring magnetic fields of ships and submarines.

RXD Event Description

1. Title: Concept Established for Total Operation Test as Basis for Evaluating Mine Performance (#137)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Overall

4. Element: Test Evaluation (Techniques)

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the establishment of an evaluation philosophy wherein overall system performance was determined by means of a realistic test approximating the planting and actuation of an entire field of preconditioned mines. The new approach to weapon evaluation was called the Total Operation Test (TOT) plan. Its principal features were the subjecting of individual components to simulated environments to accelerate the effects of age, rough handling, and vibration; the random combination of components into mine assemblies; the scrupulous use of prescribed test and assembly procedures; the use of random combinations of planting conditions, delay-rise times, mooring depth, and ship counts.

b. Relationship to Contemporary Science and Technology:

The long series of nonredundant elements comprising the mine Mk 56 system made it impossible to demonstrate the reliability of the system by means of component and subsystem performances. This event introduced a plan for the testing of entire systems, beginning with the accumulation of approximately fifty individual components from the several vendors and manufacturers, through the complete stockpile-to-target sequence, and ending with actuation of the mines by a target vessel. By this approach, a meaningful reliability figure could be established indicative of the likely performance of the mine in service. The previous plan, wherein the reliability of the system was calculated from individual reliabilities of components and subsystems, was not realistic in that tests of these parts are intentionally extreme. Any overall figure based upon these test would be unfairly low and misleading.

Prepared By: Donald E. Sullivan, NOL (WO) Date: 7 Mar 66

5. Technical Significance: - Continued

c. Relationship to Succeeding Development or to System Performance·

This event permitted demonstration of mine performance under typical combinations of service conditions, ranging from mild to quite severe, with only thirty samples of each component. By making the testing more realistic, the reliability figures cited for complete weapon systems are made much more meaningful to the fleet.

6. Type of RXD Event: Advanced Development

7. Key Personnel:

J. H. Boeckel, Project Engineer, Ordnance Surveillance Branch, Technical Evaluation Department, NOL. Conceived the basic idea and worked out many of the details that were eventually used.

D. E. Sullivan, Project Engineer, Ordnance Surveillance Branch, Technical Evaluation Department, NOL. With Boeckel, conceived this event and worked out details.

H. E. Wolf, Project Engineer, Technical Evaluation Department, NOL. Was in charge of the evaluation of the mine Mark 56. Contributed to the concept and incorporated it into the overall technical evaluation plan.

W. C. Chamberlin, Assistant Project Manager for the mine Mark 56. Has worked largely in the field of electrical engineering. Made several significant contributions to the concept and helped incorporate it into the overall technical evaluation plan.

8. Date of Event:

a. Termination: 1954

b. Initiation: 1954

9. Duration: Six weeks

10. Organization:

a. Naval Ordnance Laboratory, White Oak

10. Organization:- Continued

b. Technical Evaluation Department

c. Mechanical Evaluation Division

d. Ordnance Surveillance Branch

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds

b. Duration- Six weeks

c. Amount- Estimated $4,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

The TOT was employed in the technical evaluation program for the mine Mark 56. The concept, with variations, has since been used by NOL in many evaluations of naval ordnance systems.

b. Previous Activity:

The overall philosophy was adapted in part because the limited test sites and target vessels precluded the implementation of random selection of field test environments and sensitivity settings.

14. RXD Event Circumstances:

This event has resulted in substantial savings. By proper planning the hardware required for evaluation can be reduced in quantity, yet the findings can be more meaningful than is possible with any plan that depends largely on the testing of components and subsystems.

15. Sources

Persons Interviewed:

L. J. Lofthus, NOL

15. Sources:- Continued

Persons Interviewed:

H. E. Wolf, NOL

W. C. Chamberlin, NOL

## RXD Event Description

1. Title: Feasibility Established for Elimination of Conventional Booster and Explosive Trains (#89)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Explosive

4. Element: Explosive Sections Mk 1 and Mk 2

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the consolidation of the booster and sub-booster typically used in the explosive train of a naval mine into a single unit capable in itself of firing the main charge.

b. Relationship to Contemporary Science and Technology:

At the time of this event, the conventional explosive train of a mine consisted of an electrically activated detonator which fired through a tetryl lead into a tetryl sub-booster which, in turn, fired the main booster filled with Composition B explosive to thereby explode the main charge of HBX. Each of the explosive-loaded elements in any firing train must be handled and stored with due regard to its hazardous nature. Obviously, any reduction in the number of explosive elements in a given system will relieve a potential safety problem, reduce the need for magazine space, and save money otherwise required for its procurement in handling. This event established that a single booster containing 25 grams of tetryl was sufficient to fire the main charge of the mine Mark 56 with a probable reliability of 99.9 (%).

c. Relationship to Succeeding Development or to System Performance:

The small amount of tetryl was incorporated into the explosive column of the arming device and the booster proper was eliminated. Later, the firing train of the mine Mark 57 was also changed to take advantage of these findings after it was demonstrated that its reinforced-plastic barrier was not a handicap.

Prepared By: Leon J. Lofthus, NOL (WO) Date: 16 Mar 66

5. Technical Significance:- Continued

Several advantages were gained by the elimination of the main booster from the firing train for the mine Mark 56. The loading characteristics of the warhead were considerably improved. The booster well which projected into the warhead had been judged objectionable by the Naval Mine Depot at Yorktown because it obstructed the filling hole and thereby contributed to possible voids in the main charge. The elimination of the booster also permitted manufacturing and handling economies. As the function of the booster was absorbed by the arming device, the efficiency and reliability of the entire train was increased.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

J. E. Ablard, Chief, Explosives Research Department, NOL. Conceived the idea that the conventional firing trains could be simplified by consolidating the main and sub-boosters and assigned the study task.

R. McGill, Chief, Explosives Property Division, Explosives Research Department, NOL. Directed the study task in this event.

R. H. Stresau, Explosives Engineer, Explosives Property Division, Explosives Research Department, NOL. With Hampton and Starr, planned and conducted the extensive testing essential to the proof of the new explosive train.

L. D. Hampton, Explosives Engineer, Explosives Property Division, Explosives Research Department, NOL. Worked with Stresau and Starr on this event.

L. E. Starr, Explosives Engineer, Explosives Property Division, Explosives Research Department, NOL. Worked with Stresau and Hampton on this event.

8. Date of Event:

a. Termination: 1953

b. Initiation: 1953

9. Duration: Four months

10. Organization:

    a. Naval Ordnance Laboratory, White Oak

    b. Explosives Research Department

    c. Explosives Property Division

11. Organization Type: Government Laboratory

12. Financial Support:

    a. Source- Navy (Bureau of Ordnance) funds

    b. Duration- Four months

    c. Amount- Estimated $12,000

13. System Interface Activity:

    a. Contemporary and Succeeding Activity:

This event was used in the mine Mark 56. It was also applied to the mine Mark 57 and to subsequent mines designed by NOL.

    b. Previous Activity:

In February 1953, an NOL group was convened by the mine Mark 56 project manager, L. J. Lofthus, to confirm the proposed explosive train design for this mine. The train was of the conventional type. Ablard suggested that the train might be simplified by the consolidation of the booster and sub-booster into a single unit. He noted the fact that the main charge of HBX-3 was almost as sensitive to booster initiation as the booster explosive itself (Composition B)--a situation which suggested to him that the booster seemed unnecessary. However, it was appreciated that the elimination of the booster would result in a substantially larger aggregate of barriers and gaps between the sub-booster and the main charge than existed between the sub-booster and the main booster. Therefore, it was necessary for NOL to conduct a large number of tests using one-pound charges of HBX to determine if the reliability of the explosive train would be degraded. In part, panels of manganese nickel steel were used to represent

13. System Interface Activity:- Continued

present the explosive section of the mine Mark 56; correspondingly, panels made of glass-reinforced plastics were used to represent the explosive section of the mine Mark 57. In addition to proving that the sub-booster and main booster could be consolidated into a small explosive unit containing only 25 grams of tetryl, it was also shown that, where a heavy barrier must be defeated, the effectiveness of the booster is enhanced by an air gap between the booster cup and the barrier. Most of the experimental effort consisted of using the Bruceton Method to determine the critical thicknesses of the air and metal barriers interposed between the booster explosive and the main charge.

14. RXD Event Circumstances: None

15. Sources:

Documents:

R. H. Stresau, L. D. Hampton, and L. E. Starr, Boosting requirements of mines, NAVORD Report 4277.

NOL reports and memoranda relating to the explosive initiation of the mine Mark 56.

## RXD Event Description

1. Title: Feasibility Established for Command System for Remote Release of Mine Case from Anchor To Facilitate Testing in Deep Water (#132)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Overall

4. Element: Evaluation Techniques

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event involved the design, fabrication and demonstration of an underwater command release system which facilitates testing by causing a moored mine to surface upon receipt of coded explosive signals. The system consists of a receiving hydrophone, a timer coder, a battery power supply, and a waterproof container to house these components. The timer coder is an electronic device utilizing bi-stable magnetic cores, transistors, and other related devices. When the proper time-sequenced signals are received by the hydrophone, the timer coder generates an electrical output pulse sufficient to fire an explosive driver.

   b. Relationship to Contemporary Science and Technology:

The full examination and evaluation of a naval mine requires that the unit be recoverable. Obviously, a time delay could be used to unlock the cable reel in the anchor and allow the buoyant case to come to the surface. However, this would require the use of surface craft to start a search when the present time was expected to expire; the time might not be exact, particularly if the test time was a period of weeks or months, and ship time would be wasted. Moreover, the time might run out during a storm which could handicap the search and recovery, even to the extent of keeping the ship in port. This event provided a system wherein the anchor could be commanded to release its lock on the mooring system whenever it was opportune to recover the mine. It was the first demonstration of a system which uses acoustic transducers, magnetic core solid-state logic circuits, explosive drivers, and mechanical interlocks with the mine anchor to cause a moored mine to surface upon remote command by means of explosive charges.

Prepared By: S. J. Black, NOL (WO) Date: 3 Feb 66

5. Technical Significance:- Continued

c. Relationship to Succeeding Development or to System Performance:

This event improved system performance by minimizing the equipment required to generate and receive a command signal. The Command Release System (CSR) is relatively immune to operation by false signals or natural causes and is effective for an unattended life of at least two years.

6. Type of RXD Event: Advanced Development

7. Key Personnel:

S. J. Black, Mechanical Engineer, Mechanisms Division, Underwater Mechanical Engineering Department, NOL. Conceived this event. Established the coding arrangement and general mechanical design, and functioned as lead engineer in the development and proof of the system.

D. W. Kuester, Chief, Acoustics and Electronics Division, Underwater Electrical Engineering Department, NOL. Assisted Black in the development and reduced the coding idea to a practical system.

I. C. Henschen, Mechanical Engineer, Structures Division, Underwater Mechanical Engineering Department, NOL. Designed the mooring release system.

R. J. Smollett, Electrical Engineer, Mechanical Evaluation Division, Underwater Evaluation Department, NOL. Developed and tested the electrical and acoustic features of the system.

N. M. Miraldi, Electrical Engineer, Mechanical Evaluation Division, Underwater Evaluation Department, NOL. Developed and tested the electrical and acoustic features of the system.

8. Date of Event:

a. Termination: 1961

b. Initiation: 1961

9. Duration: Nine months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. 1. Underwater Mechanical Engineering Department

2. Underwater Electrical Engineering Department

3. Underwater Evaluation Department

c. 1. Mechanisms Division

2. Acoustics Division

3. Mechanical Evaluation Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds

b. Duration- Nine months

c. Amount- Estimated $50,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was successfully used with the mine Mark 56 and is adaptable to any similar system, including the mine Mark 57.

b. Previous Activity:

The CRS was conceived by NOL to provide a new field test technique for the investigation of moored mines. The motivation was the need for a simple command system requiring a minimum of support equipment and capable of being used in deep waters and of recalling mines whose location could be approximated within one mile. It was decided that the simplest method of commanding release of the anchor cable was by means of a series of three

13. System Interface Activity:- Continued

time-coded acoustical signals. These acoustical signals were generated by small explosive charges such as SOFAR sound signals Mark 22 Model 0. The SOFAR bomb is depth actuated and may be set to explode at various depths from 1500 to 400 feet in increments of 500 feet. It contains a four-pound TNT charge. The timing between explosions in a signal sequence is accomplished with an ordinary watch.

14. RXD Event Circumstances:

The long-range mine plans at NOL include investigating the feasibility of planting moored mines in deep water. These plans include planting some experimental deep water mines. The CRS was developed as a tool to recall these experimental mines to permit examination of the recovered mooring system hardware.

15. Sources:

Documents:

NOL reports and memoranda pertaining to CRS.

NOLTR 64-64: Proceedings of the Seventh Conference on "The Naval Minefield: Its Objectives" (U), by B. P. Ramsay, dated 27, 28 January 1964

## RXD Event Description

1. Title: Investigation of Mine-Case Motion and Dip as Function of Currents and Wave by Means of Models (#133)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Overall

4. Element: Test and Evaluation (Techniques)

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event involved the study, by means of models, of mine-case shapes to determine the optimum configuration for reducing mine-case dip (vertical displacement due to water current) and improving mine-case stability. Out of these studies came the basic shapes for the mine cases for the mines Mark 56 and Mark 57.

   b. Relationship to Contemporary Science and Technology:

Prior to this event, during the development of the mine Mark 10 Model 3 early in World War II, it had been found that a reduction in mine-case dip could be achieved if the mine case was moored in a horizontal plane rather than a vertical plane. The shape of this mine case, however, was not streamlined and in addition to having high drag and consequently high dip, it was unstable in the water and oscillated severely. Movement of this magnitude could not be tolerated in the mines Mark 56 and Mark 57 with their more sensitive mechanisms. Through this study, configurations were achieved which reduced drag and increased stability consistent with the mine requirements.

   c. Relationship to Succeeding Development or to System Performance:

This event increased the effectiveness of the system by reducing the dip and movement in the mine case.

Prepared By: Leon J. Lofthus Date: 1 Mar 66

6. Type of RXD Event: Exploratory Development.

7. Key Personnel:

N. Brown, hydrodynamicist, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. Proposed and tested various envelopes for the mine case.

M. W. Crawford, mechanical engineer, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. With Henschen and Goss, refined the parabolic tail shape into an elliptical shape and added stabilizing fins and an encircling shroud.

I. C. Henschen, mechanical engineer, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. Worked with Crawford and Goss.

R. J. Goss, mechanical engineer, Mine and Depth Charge Division, Underwater Ordnance Department, NOL. Worked with Crawford and Henschen.

L. G. Avelyra, mechanical engineer, Towing Problems Branch, Stability and Control Division, DTMB. Conducted tests associated with this event.

8. Date of Event:

a. Termination: 1952

b. Initiation: 1952

9. Duration: Five months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Underwater Ordnance Department

c. Mine and Depth Charge Division

10. Organization:- Continued

d. David Taylor Model Basin (DTMB)

e. Stability and Control Division

f. Towing Problems Branch

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds.

b. Duration- Five months.

c. Amount- Estimated $8,000.

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used to establish the case envelopes and stabilizing arrangements for the mines Mark 56 and Mark 57. The original shape selected by Brown was satisfactory for the mine case as conceived at that time. As the weight of other components increased during early development, improvements in the case design yielding higher displacement without loss in stability were required. Mechanism compartments Mark 1 Model 0 and Mark 2 Model 0 for the mine Mark 56 and explosive sections Mark 1 Model 0 and Mark 2 Model 0 for the mine Mark 57 were the outgrowths of these basic designs. In addition, a library of current velocity profiles from various worldwide locations was matched with mine-case hydrodynamic data and programmed through a computer to give accurate predictions of dip. These predictions are used by the fleet in establishing case depth and mooring parameters for minefield planning operations.

b. Previous Activity:

The need for a stable mine case compatible with the firing system

13. System Interface Activity:- Continued

for the mines Mark 56 and Mark 57 motivated NOL to pursue this investigation. A team of mine design specialists and hydrodynamic experts from NOL and DTMB cooperated in this event.

Models of experimental case designs for the subject mines were made and tested by DTMB. The lift, drag and dip characteristics of these shapes were determined under various current conditions. DTMB also conducted a theoretical investigation to determine the mooring cable's forces and configurations which would be experienced at sea. Tables of lift, drag, cable configuration, mooring-line tension, and mooring-line angles as a function of speed were established, and optimum case envelopes were evolved. Special shrouds and fins were designed to improve the stability of the shape, and a rigid mooring arrangement was provided which shifted the mooring-cable attachment point a short distance from the case to thereby improve the restoring force in the event the case was displaced from its true position.

14. RXD Event Circumstances: None

15. Sources:

Persons Interviewed:

M. W. Crawford, NOL.

I. C. Henschen, NOL.

## RXD Event Description

1. Title: Invention of Underwater Telemetry System To Monitor Mine Response in Ocean (#135)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Overall

4. Element: Test and Evaluation (Equipment)

5. Technical Significance:

   a. Origin, Technical Activity and Outcome:

This event concerns the invention of an underwater telemetry system for monitoring the "look" and "fire" actuations of naval mines, thus avoiding the need for monitoring cables between the test weapons and recording stations on shore.

   b. Relationship to Contemporary Science and Technology:

At the time of this event, mine response was monitored via electrical cables. This technique was satisfactory for bottom mines because the cable could easily be led from the mine across the ocean floor to recording stations on the beach. Moored mines presented a different situation, however, because the firing system is housed in the buoyant case which is tethered by a mechanical wire rope to its anchor. Electrical cables from the case to the beach would restrict the natural movement of the mine in the sea; this movement, if severe, can affect the performance of the system and should not be restrained in mine-response tests. In addition, special planting techniques would be required to moor a mine outfitted with test cables to shore. This event made it possible to moor mines for test purposes in a manner nearly identical to the anticipated use situation. It was then possible to repeatedly pass ships near these mines and note the response of the mechanism to various target situations. "A patent was issued."

Prepared By: R. J. Smollett  Date: 27 Feb 66

5. Technical Significance:- Continued

c. Relationship to Succeeding Development or to System Performance:

The use of the telemetry system by the mines Mark 56 and Mark 57 improved their performance,because the mines could be planted in the normal manner without restrictions on the launching mode and without the encumbrance of auxiliary cables.

6. Type of RXD Event: Exploratory Development.

7. Key Personnel:

D. D. Woolston, physicist, Field Test Division, Technical Evaluation Department, NOL. Responsible for this event and is recognized as co-inventor in the patent for this invention.

N. N. Miraldi, electronics engineer, Field Test Division, Technical Evaluation Department, NOL. Co-inventor, with Wooiston, of this system.

M. J. Aucremanne, physicist, Field Test Division, Technical Evaluation Department, NOL. Provided consulting services.

W. H. Mannina, physicst, Field Test Division, Technical Evaluation Department, NOL. Provided consulting services.

C. E. Goodell, electrical engineer, Field Test Division, Technical Evaluation Department, NOL. Assisted in the design of this system.

R. J. Smollett, electrical engineer, Field Test Division, Technical Evaluation Department, NOL. Assisted in the design.

8. Date of Event:

a. Termination: 1956

b. Initiation: 1954

9. Duration: Approximately eighteen months.

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Technical Evaluation Department

c. Field Test Division

11. Organization Type: Government Laboratory.

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds under Project 435-164/46022/44 040, Project C?a-325-1-56, and Task No. 431-064-46020/01 040.

b. Duration- Approximately eighteen months.

c. Amount- Estimated $100,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

The telemetry system was ued to transmit information regarding the response of mine-firing mechanisms to a shore-based recording station. This response information was transmitted over an acoustic communication channel. The life of the telemetry system was comparable to that of the mine. After the feasibility of using the telemetry system for monitoring mine response was established, several sets of hardware were manufactured by NOL personnel. This equipment was installed in mines which were moored off Ft. Lauderdale. Numerous target ships passed near these mines, and the response data was recorded at a shore facility. This data constituted a major portion of the response data used in evaluating the mine designs of both the mines Mark 56 and Mark 57.

b. Previous Activity:

NOL's Technical Evaluation Department was responsible for performing test and forwarding recommendations on the technical suitability

13. System Interface Activity:- Continued

of the mine design. This event was motivated by the desire to conduct the technical evaluation tests as realistically as possible. The shortcomings of the cable technique were well known to those who had been testing mines, including Woolston and Miraldi. They were associated with Smollett, who had been using radio-telemetry techniques to test other weapons. The idea of using an underwater telemetry system as a means of circumventing the cable problems was an outgrowth of these circumstances.

14. None

15. Sources:

D. D. Woolston and N. N. Miraldi, "The mine Mark 56, monitoring by use of a transistorized telemetering system," NOL Technical Note 3574, 17 May 1956.

## RXD Event Description

1. Title: Development of Laboratory Technique and Facility for Determining Water-Entry Shock Signatures of Air-Launched Underwater Weapons (#143)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Overall

4. Element: Test and Evaluation (Facility) (Techniques)

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event involved the development of a laboratory facility and instrumentation for determining the water-entry shock signatures of underwater weapons through the use of large-scale models. Under the controlled conditions possible with this facility, shock signatures are studied as a function of entry velocity and angle of entry; data are taken at various locations throughout the weapon assembly. The findings are used in the establishment of design and evaluation criteria.

b. Relationship to Contemporary Science and Technology:

This event provided the first opportunity to obtain acceleration-time data under controlled conditions using large-scale (1/4 to 1/2 size) models of prototype weapons. Previous efforts had been confined to studies using small-scale models with only photographic coverage or full-scale field trials with the attendant problems of instrumentation and lack of precise control of entry conditions. Studies using this facility were largely focused on investigations of the shock associated with the flow establishment phase, considered for most water-entry experiences to be the most severe from a shock standpoint.

c. Relationship to Succeeding Development or to System Performance:

This event greatly increased the understanding of water-entry shock environment. The test facility was an economical and productive way to examine problems of failure. This facility was limited to prototype velocities

Prepared By: G. Stathopoulos, NOL (WO) Date: 2 Mar 66

5. Technical Significance:- Continued

up to 500 fps; most of the data required for velocities up to this value had been obtained. Work beyond these velocities will be conducted on both a research and applied basis in the NOL Hydroballistics Facility now nearing completion.

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

J. H. Armstrong, Evaluation Specialist, Environment Simulation Division, Technical Evaluation Department, NOL. Provided design criteria for the facility and headed the team responsible for the design.

M. B. Tate, Evaluation Specialist, Environment Simulation Division, Technical Evaluation Department, NOL. Provided the design concept and designed the seismic platform and tank.

V. F. DeVost, Evaluation Specialist, Environment Simulation Division, Technical Evaluation Department, NOL. Designed the propulsion system and demonstrated the feasibility of the facility through a working model.

J. W. Simkins, Evaluation Specialist, Environment Simulation Division, Technical Evaluation Department, NOL. Designed the propulsion system, with DeVost, and demonstrated the feasibility of the facility through a working model.

J. H. Boeckel, Evaluation Specialist, Environment Simulation Division, Technical Evaluation Department, NOL. Designed the device used to incline the water surface.

W. E. Parsons, Evaluation Specialist, Environment Simulation Division, Technical Evaluation Department, NOL. Devised the instrumentation, with others.

G. Stathopoulos, Evaluation Specialist, Environment Simulation Division, Technical Evaluation Department, NOL. Devised the instrumentation and obtained and analyzed data.

L. A. Vagnoni, Evaluation Specialist, Environment Simulation Division, Technical Evaluation Department, NOL. Devised the instrumentation and obtained and analyzed data.

7. Key Personnel:- Continued

R. Chaplick, Evaluation Specialist, Environment Simulation Division, Technical Evaluation Department, NOL. Obtained and analyzed data.

J. L. Luttrell, Evaluation Specialist, Environment Simulation Division, Technical Evaluation Department, NOL. Obtained and analyzed data.

M. Kornhauser, Evaluation Specialist, Environment Simulation Division, Technical Evaluation Department, NOL. Obtained and analyzed data.

R. F. Mead, Evaluation Specialist, Environment Simulation Division, Technical Evaluation Department, NOL. Obtained and analyzed data.

8. Date of Event:

a. Termination: 1953

b. Initiation: 1953

9. Duration:

Six months for design and instruction. The data gathering continued from mid 1953 to 1961, when there was no longer a need for this facility.

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Technical Evaluation Department

c. Environment Simulation Division

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Ordnance) funds

b. Duration- Six months; funds were available as required

12. Financial Support:- Continued

c. Amount- Estimated $66,000

d. Of this amount, $60,000 was used for the development and construction of the facility and instrumentation under the BETTY program. An estimated $6,000 was used to gather data for the mine Mark 56 program.

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

Data obtained by means of this facility were used as a basis for design and evaluation criteria and for establishing laboratory simulation techniques. The investigations for the mine Mark 56 were confined to normal (vertical) entries for which insufficient data were available. Subsequently the facility was used for water-entry studies for the rocket-propelled, nuclear depth bomb Mark 28 (SUBROC). This facility was also used during an investigation to determine the shock encountered by General Electric Company and AVCO designs of full-scale data capsules used with reentry vehicles.

b. Previous Activity:

In the course of designing and evaluating underwater weapons from the standpoint of water-entry shock, most of the information used was evolved from theoretical studies and field measurements. In many cases this information was inadequate and often conflicting. The particular shock-pulse phase of primary interest was the flow-establishment phase. During the design of the first nuclear depth bomb (BETTY), it became necessary that the shock signature be determined at the location of a critical Atomic Energy Commission component. This requirement set the stage for the development of a facility for launching relatively large-scale models (1/4 to 1/2 of prototype) into water under controlled entry conditions. In this manner the shock signatures could be obtained through accelerometers mounted in the weapon.

With this facility, it was then possible to investigate the shock associated with the successor to BETTY, the nuclear Depth Bomb Mark 101 (LULU), on water entry. The data was needed because there was relatively little shock information on the novel head shape that was used.

13. System Interface Activity:- Continued

The investigations were continued on the Mine Mk 56. Here, field tests had revealed that an unexpected failure of the anchor occurred when the mine was dropped from high altitudes. The forward face of the anchor, a heavy plate of steel, was found to "dish" in and block rotation of the cable reel. It was speculated that, if the mine were to enter smooth water on a truly vertical trajectory, the peak shock loads experienced by this face might be sufficient to deform it. It was not feasible to run full-scale air drops to prove this theory, because a large number would be necessary to encounter even one where the conditions were proper. With this test facility, it was found that the loads imposed upon the anchor face were an order of magnitude greater at $90^{o}$ entry than the loads experienced when the entry angle was even $5^{o}$ from the vertical.

14. RXD Event Circumstances:

NOL was aware of the importance of the water-entry shock environment as early as 1942. Small-scale model studies were conducted using crude techniques, by modern standards, to study this environment. Facilities were also constructed to simulate these shocks in the laboratory. By and large, however, the simulation techniques used were refined through comparison of field and laboratory failures.

15. Sources:

Persons Interviewed:

J. H. Armstrong, NOL.

J. C. New, NOL

J. L. Luttrell, NOL

Documents:

Paper presented at U.S.N. Bureau of Ordnance Hydroballistics Symposium held at Stevens Institute of Technology, 9-12 September 1957, entitled "Water entry signature facility and results of program conducted using large scale models."

15. Sources:- Continued

NAVORD Report 4527, Water entry signature facility.

NAVORD Report 4541, A study of the SUBROC water entry forces.

NAVORD Report 6082, Water entry shock studies of 0.36 scale LULU weapon.

NAVORD Report 4136, Evaluation report for bomb, depth Mk 80 Mod 0. Vol. 2, Appendix B-5.

RXD Event Description

1. Title: Development of Deep-Water Inspection System for Minefields by Remote-Controlled Television Apparatus (#141)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Overall

4. Element: Test and Evaluation (Equipment)

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the introduction of a remote-controlled television system for the inspection of underwater weapon systems without disturbance to the latter. The system and its operation involves much more than the electronics of a closed-circuit TV. Its essential components include: a reasonably stable vessel capable of from a single to a four-point adjustable moor; a plotting system capable of pinpointing the original mine-planting position and camera-suspension cable to within a few feet; a television system consisting of camera and light mounting, a remote pan and tilt device, a finned frame to carry the underwater gear, power and control cables to the surface, and surface television monitors and controls; a crane to suspend the gear, with a TV monitor mounted in front of the operator's position; and an alert, sensitive crane operator who can anticipate ship movements to keep the underwater gear at the underwater spatial point desired.

b. Relationship to Contemporary Science and Technology:

With the advent of the deep-water moored mines Mark 56 and Mark 57, air- and submarine-laid, respectively, a need was established for strong, corrosion- and fouling-resistant mooring ropes, as well as corrosion- and fouling-resistant paints. Candidate materials had to be investigated in a sea environment at depths exceeding 150 feet. Heretofore, divers were used to inspect units planted for these purposes. However, 150 feet is about the practical limit for repetitive diver inspections and, even at depths of 150 feet, diver endurance is short and little time is available for a thorough visual and photographic inspections. Consequently the necessarily frequent (monthly or quarterly) inspections were slow, inadequate and expensive. With the use of this event, technical personnel on the surface can observe and study planted ordnance units and components for as long as necessary, without disturbing or putting strains on the item of interest. Case attitudes and changes, fouling buildup, deterioration and disintegration of paint and materials, and extent

Prepared By: A. D. Yensen, NOL (WO) Date: 14 Mar 66

5. Technical Significance:- Continued

of corrosion can be observed. Useful observations can be made which otherwise could not be made at all—or, at best, would involve recovery, gross strains, breakage, and disturbing of paint, fouling, and marine organisms.

c. Relationship to Succeeding Development or to System Performance:

This system proved to be a valuable aid in the inspection of the mooring systems and the protective coatings for the mines Mark 56 and Mark 57.

6. Type of RXD Event: Advanced Development

7. Key Personnel:

W. M. Taylor, Senior Technical Representative, NOL. Conceived this event and headed the team effort in its development.

G. B. robbins, Station Employee, NOL Test Facility, Fort Lauderdale. Team member.

E. Payne, Station Employee, NOL Test Facility, Fort Lauderdale. Team member.

H. E. Bowen, Station Employee, NOL Test Facility, Fort Lauderdale. Team member.

T. D. Outten, Station Employee, NOL Test Facility, Fort Lauderdale. Team member.

8. Date of Event:

a. Termination: 1958

b. Initiation: 1958

9. Duration: Three months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

10. Organization:- Continued

    b. Technical Evaluation Department

    c. Test Facility, Fort Lauderdale

11. Organization Type: Government Laboratory

12. Financial Support:

    a. Source- Navy (Bureau of Ordnance) funds

    b. Duration- Three months

    c. Amount- Estimated $18,000

13. System Interface Activity:

    a. Contemporary and Succeeding Activity:

The first mine Mark 56 and Mark 57 life tests which used the underwater television system were made in October 1958. Each field included from 3 to 20 mines; since then, the original groups have been recovered and new groups planted once or twice a year each year to the present time.

    b. Previous Activity:

The mines Mark 56 and Mark 57 are outfitted with advanced-design firing systems that are capable of operation for many months after planting. However, as moored mines, they are effective only if their buoyant cases remain free of marine fouling (if not, marine growths will increase the drag of the cases so that currents will cause them "dip" and drop below their intended positions) and if their mooring lines are free of corrosion which could cause the latter to weaken and break. Marine growths on exposed hydrophone surfaces could hamper the efficiency of one of the optional firing systems. By related events, poison compounds and protective paints were devised to prohibit fouling and restrict corrosion. To inspect test units planted in deep water, it is essential that the units be accessible for close study without need for disturbing the system; i.e., physical recovery of a test unit would likely upset the condition of interest and the unit would be lost for further testing. For this reason, NOL was motivated to develop the remote-controlled television system.

14. RXD Event Circumstances: None

15. Sources:

Documents:

Field Division files

RXD Event Description

1. Title: Introduction of Remote-Operated, Television-Guided, Explosive-Powered Recovery Snare for Deep-Water Use (#142)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Overall

4. Element: Test and Evaluation (Equipment)

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the development of a snare for the recovery of mines and other devices planted in deep water without need for divers or auxiliary lines.

b. Relationship to Contemporary Science and Technology:

Moored mines frequently must be planted in water depths beyond the capability of divers. It is not feasible to use recovery lines attached to the units because these lines would restrict the modes for launching and might foul the units after planting. Yet recovery of the hardware is essential for a variety of reasons. In the instance of the mines Mark 56 and Mark 57, some units were planted in water beyond diver depth to check their total operation, case-anchor separation, case dip, effects of case attitude, target response, and endurance. Recovery was necessary for access to internal recorders, to assess the units for evidence of failure, and to keep the planting area clean. This event provided a means of finding the units and then securing a hold on them.

c. Relationship to Succeeding Development or to System Performance:

This event greatly facilitated the testing and evaluation of the mines Mark 56 and Mark 57 and made feasible the recovery of mines planted in deep water.

Prepared By: A. D. Yensen, NOL (WO) Date: 14 Mar 66

6. Type of RXD Event: Advanced Development

7. Key Personnel:

W. M. Taylor, Senior Technical Representative, NOL. Team leader in this event.

G. B. Robbins, Station Employee, NOL, Test Facility, Fort Lauderdale. Team member.

U. V. Tommola, Station Employee, NOL, Test Facility, Fort Lauderdale. Team member.

A. M. Reece, Station Employee, NOL. Test Facility, Fort Lauderdale. Team member.

T. D. Otten, Station Employee, NOL. Test Facility, Fort Lauderdale. Team member.

H. E. Bowen, Station Employee, NOL. Test Facility, Fort Lauderdale. Team member.

E. Payne, Station Employee, NOL. Test Facility, Fort Lauderdale. Team member.

8. Date of Event:

a. Termination: 1960

b. Initiation: 1960

9. Duration: Three months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

b. Technical Evaluation Department

c. Test Facility, Fort Lauderdale

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds

b. Duration- Three months

c. Amount- Estimated $200,000

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This event was used in conjunction with the underwater television system developed for the inspection of the mines Mark 56 and Mark 57.

b. Previous Activity:

This event was motivated by the need to assess the operability and reliability of the mines Mark 56 and Mark 57. At the Fort Lauderdale Test Facility, station personnel led by W. M. Taylor, NOL's Senior Technical Representative, devised a running loop of wire rope and secured it to the bottom of a recovery frame; the other end of the wire was secured to a hoisting line. A remote-controlled television system was used to locate the item to be recovered and to examine the best way to latch on to it. The frame was then lowered carefully over the object, the loop of wire was dropped by firing one explosive release system, and the loop was drawn tight by slowly raising the frame.

14. RXD Event Circumstances: None

15. Sources:

Documents:

NOLTF Ft. Lauderdale files

# RXD Event Description

1. Title: Establishment of Field Facility To Obtain Mine Design, Endurance, and Response Data (#140)

2. Weapon System: Mines Mk 56 and Mk 57

3. Subsystem: Overall

4. Element: Test and Evaluation (Facility)

5. Technical Significance:

a. Origin, Technical Activity and Outcome:

This event concerns the establishment of a detached field station for full-scale sea trials of naval ordnance.

b. Relationship to Contemporary Science and Technology:

At the time of this event, existing facilities for full-scale field trials of newly developed air- and submarine-launched moored and bottom mines were grossly inadequate. In 1950 the water areas available or suitable for minefield work provided valuable geographical and physical conditions, but the following features were lacking: deep sea areas (200-fathom minimum water depth), within economical cabling and steaming distance from shore, for air drops and mine-response studies; sufficient sea room for surface vessels and submarines to make long, straight runs, comparatively free of large-ship traffic; waters safe for submerged submarine runs; waters with hard bottom for weapon-impact studies; air space for air drops into water from altitudes up to 10,000 feet, within optical tracking distance from shore; bottom areas with acoustic properties different from a primarily harbor-type environment; deep-water area where extensive moored minefields could be planted and left unmolested by traffic for periods up to two years for life tests and environmental studies; and waters with sufficient clarity to permit underwater photography. By this event, a test facility was provided incorporating these features.

c. Relationship to Succeeding Development or to System Performance:

This event played an essential part in the test and evaluation of the mines Mark 56 and Mark 57.

Prepared By: A. D. Yensen, NOL (WO) Date: 10 Mar 66

6. Type of RXD Event: Exploratory Development

7. Key Personnel:

R. E. Hightower, Chief, Technical Evaluation Department, NOL. Headed the team that established the requisites for a field facility, surveyed candidate areas, and developed a test station.

W. Byrd, Evaluation Specialist, Technical Evaluation Department, NOL. Team member.

A. D. Yensen, Evaluation Specialist, Technical Evaluation Department, NOL. Team member.

J. M. Martin, Evaluation Specialist, Technical Evaluation Department, NOL. Team member.

A. H. Peale, Evaluation Specialist, Technical Evaluation Department, NOL. Team member.

D. D. Kerstetter, Evaluation Specialist, Technical Evaluation Department, NOL. Team member.

J. R. Blouin, Evaluation Specialist, Technical Evaluation Department, NOL. Team member.

A. D. Ehnes, Evaluation Specialist, Technical Evaluation Department, NOL. Team member.

8. Date of Event:

a. Termination: 1953

b. Initiation: 1952

9. Duration: Thirteen months

10. Organization:

a. Naval Ordnance Laboratory, White Oak

10. Organization:- Continued

b. Technical Evaluation Department

c. Test Facility, Fort Lauderdale

11. Organization Type: Government Laboratory

12. Financial Support:

a. Source- Navy (Bureau of Naval Weapons) funds

b. Duration- Thirteen months. Funds were and are available for continuing support.

c. Amount- Estimated $3,000,000

d. This amount represents plant investment. A limited number of assist tasks are funded by other DOD activities.

13. System Interface Activity:

a. Contemporary and Succeeding Activity:

This field test facility served as the focal point for the experimentation, engineering tests, and technical evaluation of the mines Mark 56 and Mark 57. First project operations took place in January 1953, five months after establishment of the station. From that time to the completion of the technical evaluation of the mines Mark 56 and Mark 57, about 60 nautical miles of monitoring cable have been laid out to a depth of 1,000 feet, and mine plants and recoveries have been made in depths to 2,500 feet. From 1958 through 1965, 1,332 mines were surface- or submarine-planted and 248 air-dropped at this location; about 20 percent of these were mines Mark 56 and Mark 57. For mine-response data during this same period, NOLTF recorded 4,213 ship and 2,980 submarine runs over test minefields in depths from 30 to 600 feet.

b. Previous Activity:

The following investigations were necessary for the development of the moored mines Mark 56 and Mark 57: actuation analysis of firing systems by passage of surface ships and submarines in relatively large numbers; delayed-

13. System Interface Activity:- Continued

rise performance and mooring-reliability studies; vulnerability of system in open sea areas to countermining countermeasures and ocean environment; endurance, salt-water corrosion, and marine-fouling determinations; acoustic and pressure recordings in open sea areas for a variety of vessels; and delayed-opening flight gear, water entry, and bottom-impact studies. An investigation of all shore points showing reasonable promise revealed that Port Everglades, Florida, had the required geographical features and support facilities (Marine Corps Air Station, deep-water harbor, supply and transportation, and labor). The actual shore station was constructed on leased property on the beach at a former naval air station. A nucleus of personnel was reassigned from other NOL field stations; the remainder were hired or transferred from NOL.

14. RXD Event Circumstances:

NOL operates a full outfit of simulation equipment at the White Oak Laboratory, including a test tank with a working depth of 100 feet of water and a modest field station on the Patuxent River off Solomons, Maryland. The following combination of test facilities is typical: new systems are first shocked, vibrated, pressure-tested, if possible, in the tank; next they are air-, surface-, or tube-launched (the latter from a barge) under the somewhat restricted conditions imposed at the Solomons range; and finally they are tested and evaluated under the relatively unrestricted conditions off Port Everglades.

15. Sources:

Documents:

NOLM 16900, 24 July 1950

NAVORD 1872, 11 May 1951

NOL and NOLTF files, 1952 to 1966